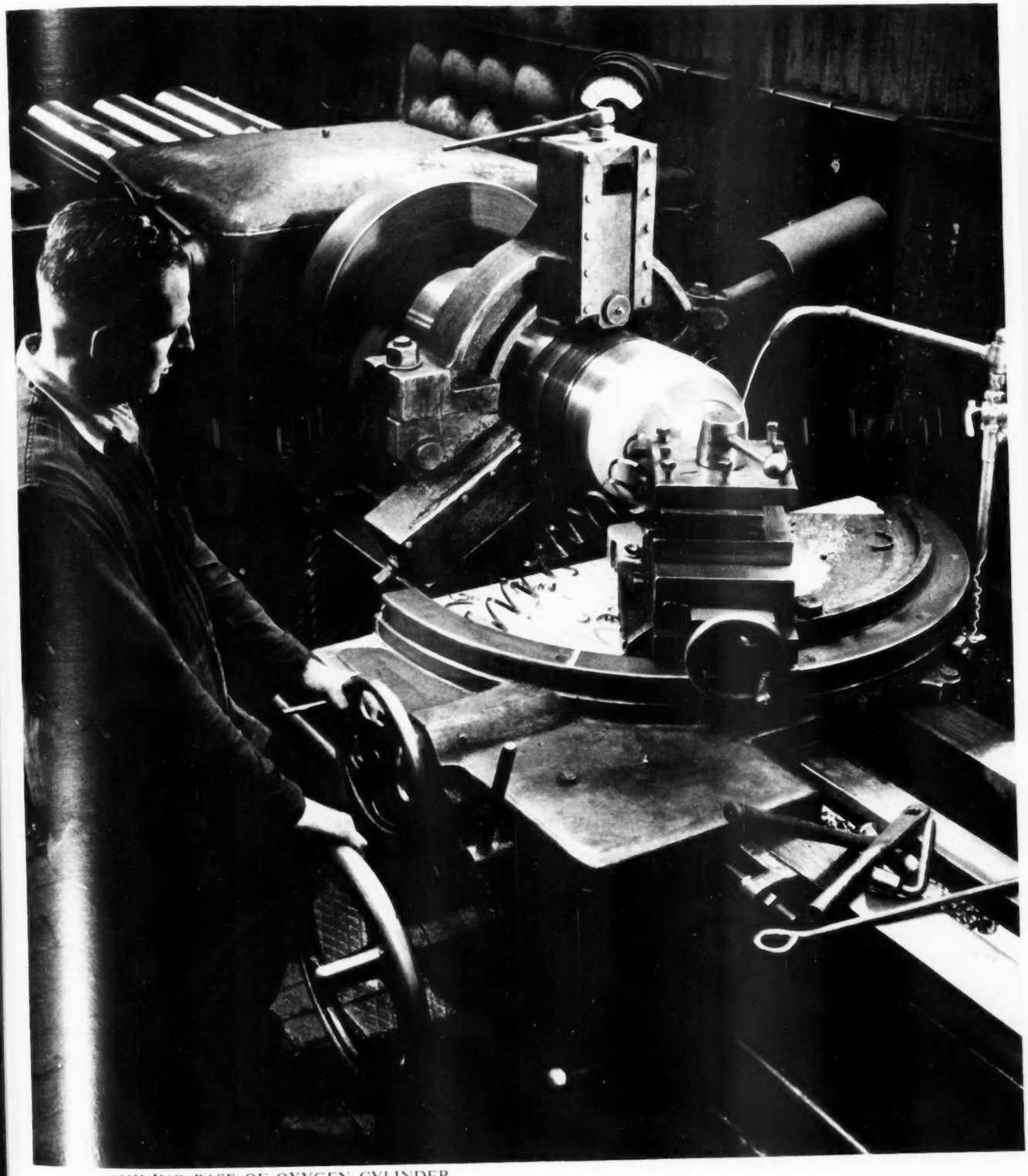
ENGINEERING

An Illustrated Weekly Journal

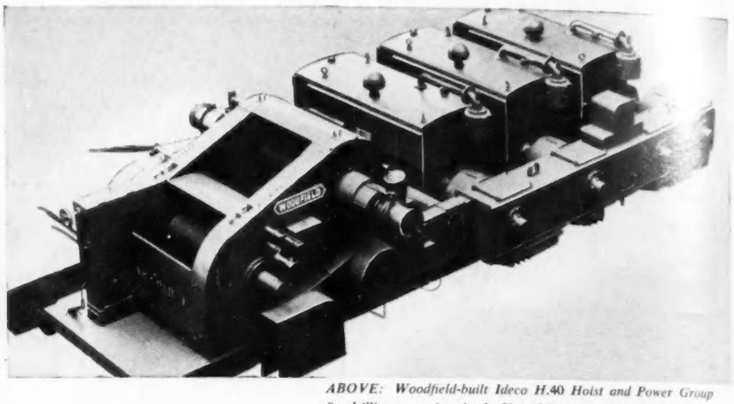
& 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 181 No. 4712 *LONDON, FRIDAY, JUNE* 29, 1956 PRICE 2s.

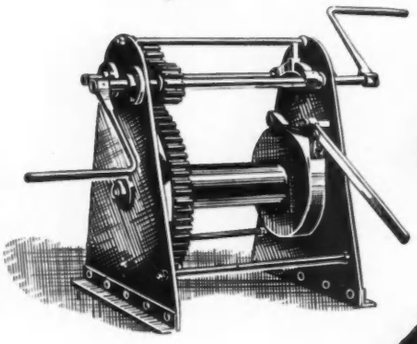


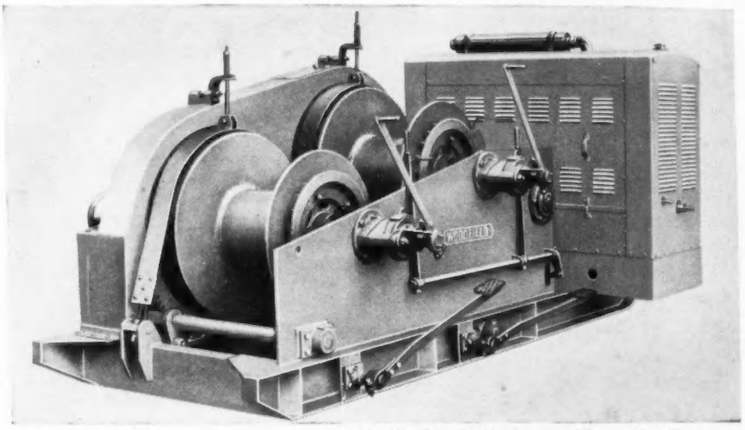
ACHINING BASE OF OXYGEN CYLINDER

From Small Beginnings

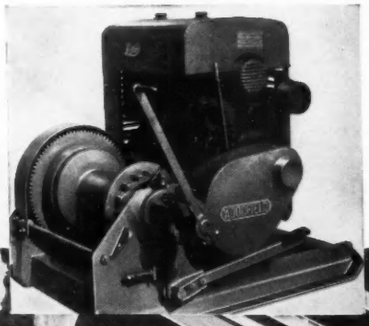


ABOVE: Woodfield-built Ideco H.40 Hoist and Power Group for drilling operations in the United Kingdom by the Gas Council, in search for Natural Gas.



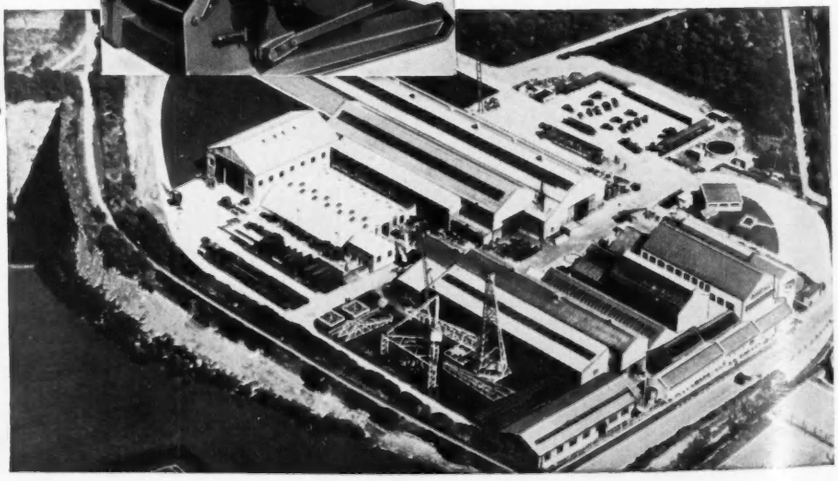


ABOVE: 5-ton Double Drum diesel-driven Piling Winch.



LEFT: Single Drum, diesel driven Winch. Capacity 1 ton.

BELOW: View of Rochester plant covering 22 acres, including Sports Ground on left.



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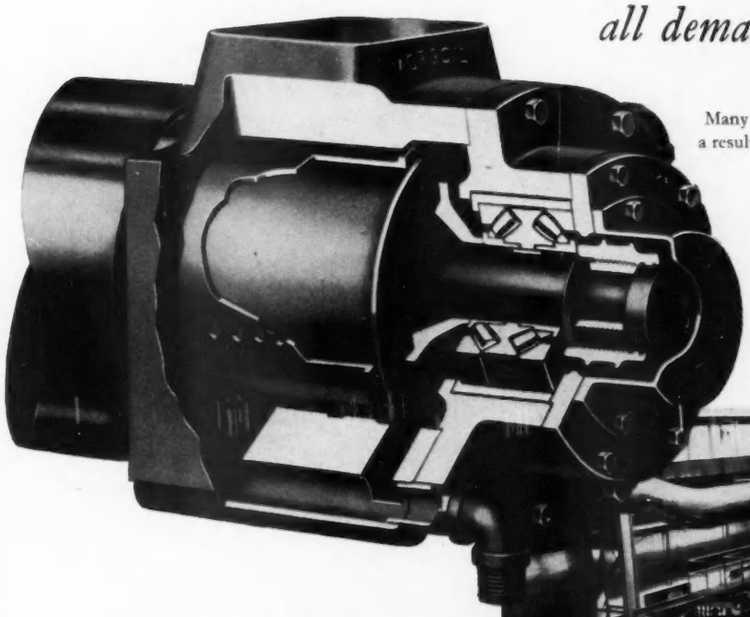
ROLL NECK BEARINGS



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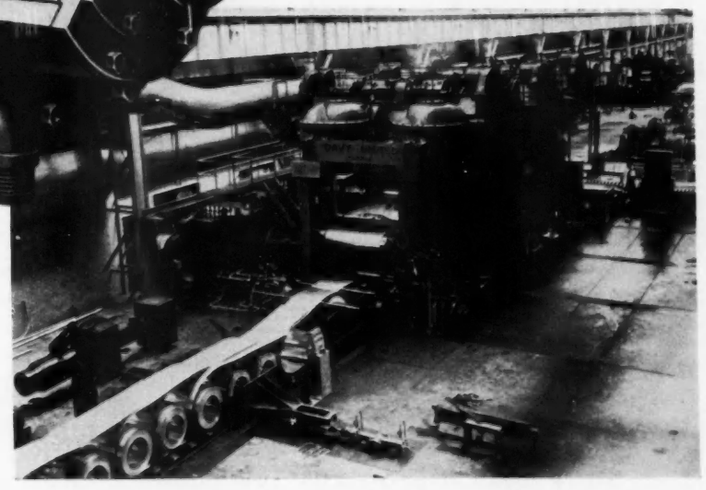

66" wide Davy-United 5-Stand Tandem Cold Strip Mill in the Rogerstone Works of Northern Aluminium Company Ltd., wherein it is rolling aluminium strip up to 56" wide down to .010" thick at 2,000 feet per minute. Back-up rolls are fitted with 44"-90 Morgoils.

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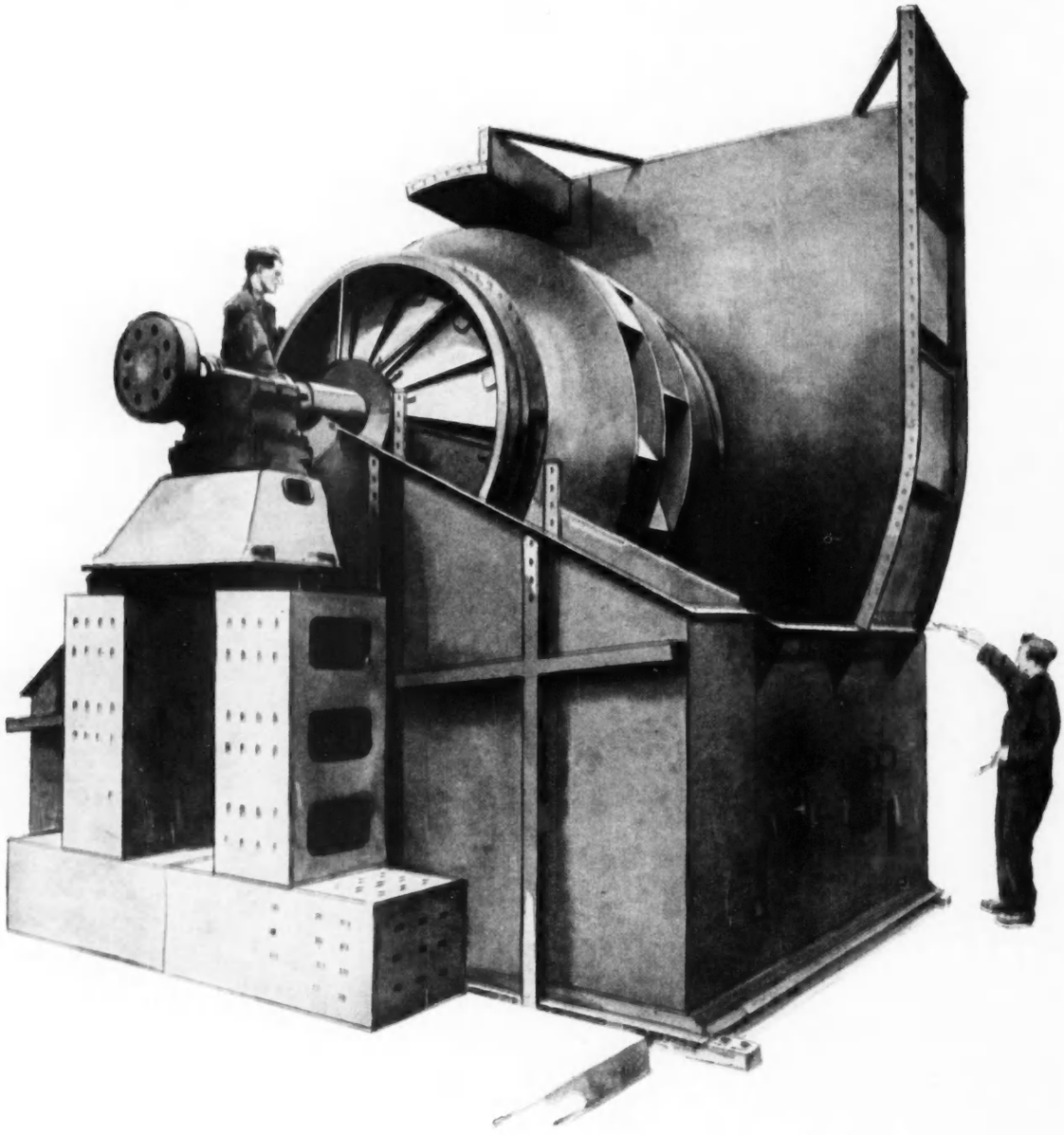

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METALLURGIST—Wanted for South African Steelworks. Assistant Works Metallurgist with knowledge chemical analysis, steelmaking, manufacture and heat treatment alloy and tool steels. Salary, £900 per annum and upwards according to experience. Good prospects. Fare paid to South Africa including family. Graduate preferred.—Apply in writing to LONDON REPRESENTATIVE, UNION STEEL CORPORATION (OF SOUTH AFRICA), LTD., 723, THE ADELPHI, LONDON, W.C.2, giving full details of experience and qualifications. M 116

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STANLEY DUMBELL,
REGISTRAR. M 108

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Applicants for the post of Design Engineer should be qualified Civil Engineers (Associate Members of the Institution of Civil Engineers or other internationally recognised body) having particular experience of the layout and design of roads (bitumen macadam and reinforced concrete) and reinforced concrete structure together with a sound working knowledge of the design of water supply, Sewerage and sewage disposal schemes. Applicants should be rapid and competent draughtsmen.

The successful applicant will assist in the design of many of the Civil Engineering works associated with a rapidly expanding town.

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SALARY: For both above appointments will be according to Scale E2. Each starting at Rs. 1,775/= an Arabic month with annual increments of Rs.75/= a month up to Rs. 2,000/= and then by annual increments of Rs. 100/= per month to a maximum of Rs. 2,300/= per month. (Rs. 1,775/= an Arabic month is equivalent to £1,590/= Sterling a Gregorian year.)

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THE ADVISER TO THE GOVERNMENT OF QATAR,
P.O. BOX NO. 36,
DOHA, QATAR,
PERSIAN GULF.

A further copy with enclosures similarly endorsed should be sent to:

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CIVIL ENGINEER.
(FIELD ENGINEER, JORDAN.)

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(ii) P.O. Telephone Practice.
(iii) Electro-mechanical equipment of the type used in remote control systems.

A good basic knowledge of electronics is desirable. Possession of H.N.C. (Electrical) would be an advantage.

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Send POSTCARD for application, which must be returned by 3rd July, 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, Nr. DIDCOT, BERKS, quoting reference 568/26. M 213

ENGINEER (BASIC GRADE) required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS, to assist senior staff engaged on planning of new buildings including mechanical and electrical installations, site services and plant.

Applicants should have served a recognised apprenticeship and possess Associate Membership of the Institute of Civil, Electrical or Mechanical Engineers or have exempting qualifications.

Experience in the field of heating and ventilating, acceptance tests of mechanical and electrical installations and works services associated with buildings containing explosives is desirable.

SALARY: £766 at age 25 to £1050 at age 34 or over on entry, rising to £1199 p.a. Contributory Superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates. Alternatively assistance towards legal expenses incurred in house purchase may be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to the SENIOR RECRUITMENT OFFICER at the above address not later than 9th July, 1956. Please quote ref. 1188/26. M 212

KENT COUNTY COUNCIL.

Applications are invited for the post of **PRINCIPAL ENGINEERING ASSISTANT** on the permanent establishment of the Buildings Department, at a salary on J.N.C. Scale F/G (£1625 by £55 to £2065).

Candidates who must be Corporate Members of one or more of the appropriate professional bodies should have considerable experience of heating, hot and cold water supply and ventilation systems, together with a good knowledge of electrical installations.

Applications, on forms obtainable from the COUNTY ARCHITECT, SPRINGFIELD, MAIDSTONE, should be delivered to him not later than the 18th July, 1956.

Canvassing in any form will disqualify.

GERALD BISHOP,
Clerk of the County Council.
County Hall, Maidstone. M 244

SHEFFIELD REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER, £640-£930, for designing heating, ventilation, steam and water schemes in Regional Engineer's Department controlling over 200 hospitals in an area of 6000 square miles. Good opportunity to gain experience designing Electrical Schemes. Car allowance and pension.—Send details: SECRETARY, SHEFFIELD REGIONAL HOSPITAL BOARD, OLD FULWOOD ROAD, SHEFFIELD, 10. M 220

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

GRADUATE MECHANICAL ENGINEER required by the Association for research on the engineering aspects of Cutlery production, with emphasis on new machines and processes. Previous experience of cutlery production not essential, but candidates who have had one or two years practical engineering experience would be preferred. Starting salary within the range £660-£900 p.a. according to age, qualifications and experience. Location of work Sheffield. Post is superannuated under the F.S.S.U.—Written applications only, quoting "C.U.I." to PERSONNEL OFFICER, B.I.S.R.A., 11, PARK LANE, LONDON, W.1. M 261

AUSTRALIA.

UNIVERSITY OF TASMANIA.

The University invites applications for the **CHAIR OF ELECTRICAL ENGINEERING.** The salary will be £A3000 per annum, and an allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the SECRETARY, ASSOCIATION of UNIVERSITIES of the BRITISH COMMONWEALTH, 36, GORDON SQUARE, LONDON, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 31st AUGUST, 1956. M 242

AUSTRALIA.

UNIVERSITY OF TASMANIA.

The University invites applications for the **CHAIR OF CIVIL ENGINEERING.**

The salary will be £A3000 per annum, and an allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the SECRETARY, ASSOCIATION of UNIVERSITIES of the BRITISH COMMONWEALTH, 36, GORDON SQUARE, LONDON, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 31st AUGUST, 1956. M 243

COVENTRY TECHNICAL COLLEGE.

Applications invited for following full-time teaching posts, mainly arising from increased establishment. Candidates should be graduates or hold good technical qualifications and where appropriate should have had industrial and/or teaching experience. Commencing date September, 1956, or later by arrangement.

MECHANICAL ENGINEERING DEPARTMENT.

LECTURERS (3 vacancies): Mechanical Engineering, Production Engineering and Work Study, respectively.

ASSISTANTS GRADE B (6 vacancies), **GRADE A** (3 vacancies) for National Certificate and Trades Courses in Mechanical and Production Engineering.

Burnham Technical Scale Salaries, at present:—
Lecturers: £965 by £25 to £1065 (men).
Assistants Grade B*: £525 by £25 to £820 (men).
Assistants Grade A*: £450 by £18 to £725 (men).
* Plus additions for qualifications and training; commencing salary dependent on previous experience.

Application forms and further particulars from DIRECTOR OF EDUCATION, NEW COUNCIL OFFICES, COVENTRY. M 210

CENTRAL ELECTRICITY AUTHORITY, EASTERN DIVISION.

Applications are invited for the following appointments in the Generation (Construction) Department at Divisional Headquarters in North London:—

CIVIL AND STRUCTURAL DESIGNER DRAUGHTSMEN.

Salary N.J.B., Schedule "D," within the range of Grades 4/5, £735 by £20 to £955 per annum including London Weighting.

The commencing salary will depend on experience and qualifications.

The candidates appointed will be required to undertake civil and structural design work, and applicants should have had experience in the design and detailing of reinforced concrete structures for heavy plants, culverts, etc., and structural steelwork as applied to industrial buildings.

Applications stating age, qualifications and experience should be sent to the CONTROLLER, CENTRAL ELECTRICITY AUTHORITY, EASTERN DIVISION, NORTHMET HOUSE, SOUTHGATE, N.14, by 7th July, 1956.

W. N. C. CLINCH,
Controller. M 256

CENTRAL ELECTRICITY AUTHORITY, YORKSHIRE DIVISION.

Applications are invited for the following appointment:—

FOURTH ASSISTANT ENGINEER, EFFICIENCY AND TESTING SECTION, GENERATION OPERATION DEPARTMENT, LEEDS.

Commencing salary within the range £660-£785 per annum, Grade 6, Class AX, National Joint Board Agreement (Schedule "B"), according to qualifications and experience, rising to an ultimate maximum of £865 per annum (Class EX).

Applicants should be educated to Higher National Certificate standard in Mechanical Engineering and should preferably have had experience of operation in modern Power Stations.

Duties will include assisting with the testing of Power Station plant throughout the Division, and the preparation of reports. The successful applicant will be based at Skelton Grange Power Station but will be expected to travel in connection with his duties.

Application forms, obtainable from the DIVISIONAL SECRETARY, (ESTABLISHMENTS), CENTRAL ELECTRICITY HOUSE, ST. MARY'S ROAD, LEEDS, 7, to be returned within 14 days of the appearance of this advertisement.

G. A. VOWLES,
Divisional Controller. M 251

LONDON COUNTY COUNCIL.

SOUTH EAST LONDON TECHNICAL COLLEGE, September, 1956.

VISITING LECTURERS. H.N. CERTIFICATE IN MECHANICAL AND PRODUCTION ENGINEERING. I. Heat Engines (Internal Combustion Engines, A.1). II. Theory of Machines or Strength of Materials, A.1 and A.2. III. Applied Mechanics, A.1. IV. Metrology, A.2. Evenings 6.45 to 9.15; pay 56s. per evening. O.N. CERTIFICATE IN MECHANICAL ENGINEERING. I. Applied Mechanics, S.3. II. Mathematics, S.3. III. Workshop Technology, S.3. 6.45 to 9.15 p.m.; 45s. per evening.—Applications from SECRETARY AT COLLEGE, LEWISHAM WAY, S.E.4, to be returned as soon as possible. (1199) M 245

NORTHAMPTON POLYTECHNIC, ST. JOHN STREET, LONDON, E.C.1.

Applications are invited for appointments in the Civil and Mechanical Engineering Department, for teaching in Degree and Higher National Certificate courses, as follows:—

1. **LECTURER IN CIVIL ENGINEERING** subjects, preferably including Soil Mechanics and/or Surveying.
2. **LECTURER IN MECHANICAL ENGINEERING** subjects, preferably including Applied Thermodynamics.

The appointments will be made from 1st September 1956 or as soon as possible thereafter.

Salary: Present scale £1001 by £25 to £1113. A revised scale, £1236 by £30 to £1398 from 1st October is now awaiting confirmation.

Further particulars and forms of application are obtainable from the Secretary, to whom applications should be sent by 14th July.

J. E. RICHARDSON,
Ph.D., B.Eng., M.I.E.E., A.M.I.Mech.E.,
Principal M 258

AUSTRALIA.

UNIVERSITY OF SYDNEY.

Applications are invited for the position of **LECTURER/SENIOR LECTURER IN ELECTRICAL ENGINEERING.** The successful applicant will be required to undertake teaching and research in the field of power engineering.

The salary for a Lecturer is within the range of £A1200—£A80—£A1750 per annum; for a Senior Lecturer £A1800—£A70—£A2150 per annum. In each case cost of living adjustment will be allowed (£A34 men, £A26 women). The salary is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Finance available for home purchase under Staff Members' Housing Scheme.

Further particulars and information as to the method of application may be obtained from the SECRETARY, ASSOCIATION of UNIVERSITIES of the BRITISH COMMONWEALTH, 36, GORDON SQUARE, LONDON, W.C.1.

The closing date for the receipt of applications, in Australia and London, is 27th JULY, 1956. M 241

COUNTY BOROUGH OF CROYDON, EDUCATION COMMITTEE.

CROYDON TECHNICAL COLLEGE, FAIRFIELD, CROYDON.

Principal: H. FALKNER, M.Sc.

Applications are invited for the following posts:—

1. **LECTURER IN THE MECHANICAL ENGINEERING DEPARTMENT.** Applicants should be qualified for, and experienced in, the work of Higher National Certificates.
2. **ASSISTANT GRADE "A" IN THE MECHANICAL ENGINEERING DEPARTMENT.** The duties involve the teaching of oxy-acetylene welding and will include the City and Guilds Heating and Ventilating Fitter/Welders' Course.
3. **ASSISTANT GRADE "B" IN THE SCIENCE DEPARTMENT.** The teaching will be mainly Mathematics.

Burnham Technical Scale (London area). Duties to commence September, 1956.

Further particulars and forms of application may be obtained from the undersigned (on receipt of a stamped addressed envelope) and completed forms should be returned to the PRINCIPAL within 14 days of the appearance of this advertisement.

R. WEARING KING,
Chief Education Officer.

Education Offices,
Katharine Street,
Croydon. M 248

TRINITY HOUSE, LONDON.

Applications are invited for an **ENGINEERING ASSISTANT (MECHANICAL)** on the Staff of the Corporation of Trinity House, the General Lighthouse Authority for England and Wales.

Applicants should be of British nationality, medically fit, and between the ages of 25 and 30 years. They must have served an engineering apprenticeship and be corporate members of the Institution of Mechanical Engineers, or have passed sections A, B and C of the examination for Corporate Membership or hold equivalent qualifications.

Applicants should be capable draughtsmen experienced in the layout and installation of internal combustion engines, compressors, auxiliary equipment and pipework. The work entails occasional site visits and applicants must be prepared to travel.

The appointment is permanent and pensionable subject to a probationary period of not less than one year. Salary £765 per annum (at age 25) rising to £1190 per annum. Maximum starting salary £900 per annum (age 30).

Applications to be made to THE SECRETARY, TRINITY HOUSE, TOWER HILL, LONDON, E.C.3, not later than 16th July, 1956, stating age, qualifications, experience and enclosing testimonials. M 249

NOTTINGHAMSHIRE EDUCATION COMMITTEE.

BEESTON COLLEGE OF FURTHER EDUCATION, HIGH ROAD, CHILWELL, NOTTINGHAM.

Principal: W. F. H. DALE, B.Sc., F.R.I.C.

Applications are invited for the appointment of **GRADE A ASSISTANT LECTURER IN MECHANICAL ENGINEERING SUBJECTS,** to commence September 1956, or as soon thereafter as possible. Ability to teach to the level of Ordinary National Certificate standard is essential. Salary: Burnham Technical Scale £450 by £18 to £725 per annum (now under review). There are additions for approved qualifications/training and increments for approved service/experience.—Please send foolscap s.a.e. to the PRINCIPAL for forms and further particulars. Closing date 13th July, 1956.

J. EDWARD MASON,
Director of Education. M 272

LONDON COUNTY COUNCIL.

ARCHITECT'S DEPARTMENT.

Vacancies for

ENGINEERING ASSISTANTS (up to £818) and **ENGINEER GRADE III** (up to £987) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from ARCHITECT (AR/EK/SE/1) THE COUNTY HALL, S.E.1. (1278). G 573

MINISTRY OF LABOUR AND NATIONAL SERVICE.

H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts. Age at least 21 and (unless exceptionally well qualified) under 30 on 1st June in the year of application with extension for regular service in H.M. Forces. London salary (including extra duty allowance where payable) £533 (at age 21), then according to age up to £708 at 26 or over, rising to £969. Somewhat lower outside London. A special increment of £25, within the scale, is granted after passing probation. Higher posts filled by promotion from Class II.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health and welfare of work-people and extend to all manufacturing industries and to certain other places, including Docks, Works of Engineering Construction and Building Operations.

Candidates must normally be university graduates, preferably in Engineering or Natural Science (or comparable technical qualification, e.g. A.M.I. Mech.E.). Graduates in other subjects, including Arts, are eligible. Works or other practical experience an advantage. Candidates without degrees (or comparable technical qualifications) who have good general or technical qualifications, and have had considerable works or other practical experience (especially in responsible positions) will also be considered. Pay and conditions of service are under review.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from SECRETARY, CIVIL SERVICE COMMISSION, 6, BURLINGTON GARDENS, LONDON, W.1, quoting No. 280. M 270

ADMIRALTY.

Vacancies exist for

LEADING ARCHITECTURAL AND CIVIL ENGINEERING ASSISTANTS in the Works Department Drawing Offices at the following Admiralty establishments: Pinner (Middlesex), Chatham, Portsmouth, Fareham (Hants), Devonport, and Londonderry (N. Ireland). Further vacancies in other areas of the United Kingdom are expected to arise shortly.

Applicants must be competent draughtsmen and experienced designers in some of the following types of building and civil engineering works: structural steelwork; reinforced concrete; dock and harbour works; residential, office, store and factory buildings; oil fuel schemes; airfield construction; rail, road, water and heating services, etc.

Posts are temporary and non-pensionable but have long-term possibilities. Opportunities for transfer to the established staff occur from time to time. Inclusive salary range £756 to £898 per annum. Entry above minimum for candidates with exceptional qualifications. The rates quoted are London rates which are slightly lower in the provinces. Candidates, who must be British subjects, are invited to apply, giving age, details of experience, etc., to CIVIL ENGINEER-IN-CHIEF, ADMIRALTY, CHAMBERLAIN WAY, PINNER, MIDDLESEX. Interview will be arranged locally. M 269

CENTRAL ELECTRICITY AUTHORITY require **ENGINEERS** in the Station Development Sub-Branch at Bankside House, London, S.E.1. The duties include the planning of new generating capacity throughout the country, the co-ordination and direction of investigations into sites for orthodox and nuclear power stations and negotiations for statutory and other consents. Candidates should possess an honours degree or the requisite qualifications for corporate membership of the Institution of Mechanical, Electrical, or Civil Engineers. A sound engineering or Scientific background is essential and experience of one or more of the problems arising in the siting of power stations, i.e., geology and ground exploration, fuel supply, use of rivers and the effects of heating, discharge and dispersal of chimney emissions and questions of town and country planning would be an advantage. Starting salaries will depend upon qualifications and experience.

Senior Assistant Engineer: £1225-£1575 p.a.
Second Assistant Engineer: £1045-£1395 p.a.
Third Assistant Engineer: £977-£1190 p.a.
Fourth Assistant Engineer: £772-£956 p.a.

Applications on Form AE6 obtainable from D. MOFFAT, DIRECTOR OF ESTABLISHMENTS, WINSLEY STREET, W.1, to be completed and returned by 12th July, 1956.
Quote Ref.: AE/838. M 266

CIVIL, MECHANICAL AND ELECTRICAL ENGINEERS are invited to apply for Short Service Commissions of 3, 4, 5 or 6 years duration in the Royal Air Force Airfield Construction Branch, followed by 4 years on the R.A.F. Reserve of Officers. The period of active service can be extended. On leaving the R.A.F., officers will be eligible for appointments in the Air Ministry Directorate General of Works. Civil Engineers must have had training in design, experience in construction, and should normally have passed Parts I and II of the Associated Membership Examination of the Institute of Civil Engineers, or have an engineering degree or equivalent. Mechanical and Electrical Engineers must have served an apprenticeship, have had practical experience and should normally hold an engineering degree or be graduates or corporate members of the Institution of Mechanical Engineers or the Institution of Electrical Engineers.—Further particulars and application forms obtainable from AIR MINISTRY, A.R.1, ADASTRAL HOUSE (A.C.2), THEOBALDS ROAD, LONDON, W.C.1. M 268

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

METALLURGIST OR ENGINEER required as Head of the Coil Spring Federation Research Laboratory in Sheffield. Applicants should be capable of taking charge of laboratory research and development work concerned with springs, their manufacture, testing and use. They should also be familiar with materials both steel and non-ferrous alloys used in spring manufacture. Honours degree in Metallurgy or Engineering with experience of academic and applied research and authorship essential. Starting salary in the range £1200 to £1700 p.a. according to age, qualifications and experience. Post is superannuated under the F.S.S.U.—Written applications only, quoting "C.S.F.1" to PERSONNEL OFFICER, B.I.S.R.A., 11, Park Lane, London, W.1. M 264

ENGINEERS: (A) CIVIL, (B) STRUCTURAL, (C) SANITARY. The Civil Service Commissioners invite applications for pensionable posts.

Age at least 25 and under 35 on 1st January, 1956, with extension for regular Forces service and appropriate civil service.

Candidates must (i) be Corporate Members of an appropriate professional institution, and, for some posts, have qualified in certain subjects, or (ii) have passed, or been exempted from, examinations necessary for obtaining Associate Membership; such candidates would be expected to qualify under (i) in due course. Professional experience expected.

London salary scale (men) £741 (at age 25) to £1160. Starting salary according to age up to £1018 at 34 or over. Lower rates outside London. Prospects of promotion to higher grades on salary scales £1160-£1500 and £1555-£1760 and above. Women's salaries lower but being improved under equal pay scheme.

Salaries and conditions of service are under review.

Further particulars and application forms from CIVIL SERVICE COMMISSION, SCIENTIFIC BRANCH, 30, OLD BURLINGTON STREET, LONDON, W.1, quoting No. 864-66/56. Completed forms should be returned as soon as possible; applications for posts (B) and (C) should be returned not later than 30th September, 1956. M 274

MIDDLESEX COUNTY COUNCIL. EDUCATION COMMITTEE.

ACTON TECHNICAL COLLEGE, HIGH STREET, ACTON, W.3.

Required, **ASSISTANT (GRADE B) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING.** Graduate or equivalent qualifications and industrial experience are desirable. Teaching duties will comprise electrical and allied subjects up to Ordinary National Certificate.

Salary in accordance with the Burnham (Technical) Report.

Application forms (stamped addressed foolscap envelope) from the Principal, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

ENFIELD TECHNICAL COLLEGE, QUEENSWAY, ENFIELD, MIDDLESEX.

Required, 1st September, 1956:

(*a*) **SENIOR LECTURER IN CIVIL ENGINEERING** to teach Civil Engineering subjects to the standard of the Final Part II of the Associate Membership Examination of the Institution of Civil Engineers.

(*b*) **LECTURER IN ELECTRICAL ENGINEERING** to teach Electronics and Radio Communications to Higher National Diploma standard.

Candidates must be University Graduates with teaching and research or industrial experience and should be corporate members of the appropriate Professional Institution.

Salary in accordance with the Burnham (Technical) Report.

Application forms (stamped addressed foolscap envelope) from the Principal, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee M 278

ADMIRALTY.

BRITANNIA R.N. COLLEGE, DARTMOUTH.

The Civil Service Commissioners invite applications from men for two pensionable posts as **LECTURER OR SENIOR LECTURER,** one in Mathematics, and one in Physics and Mechanics. For one post a qualification or experience in Art teaching also desirable. Posts to be taken up by January, 1957. Age at least 23 on 1st July, 1956. Appointment to the senior grade will depend on academic qualifications and teaching experience. Candidates must have an appropriate honours degree. Teaching experience desirable.

Inclusive salary scales: Lecturers £509-£948, Senior Lecturers £1008-£1320. Starting salary above minimum in appropriate cases. Pay and conditions of service are under review.

Full particulars and application forms from SECRETARY, CIVIL SERVICE COMMISSION, 6, BURLINGTON GARDENS, LONDON, W.1, quoting No. 4607/56/10. Completed forms should be returned by 16th July, 1956. M 277

ESSEX.

THURROCK TECHNICAL COLLEGE, GRAYS.

ASSISTANT, GRADE "B," required in September to take charge of new WELDING SHOP and to develop this subject. Initially the person appointed will also be required to assist materially with City and Guilds Machine Shop Engineering courses.

Salary (under review) £525 by £25 to £820 p.a. with additions for training and approved professional qualifications. Increments allowed for teaching, war/national service and approved industrial experience.

Details and forms (stamped addressed foolscap envelope) from the CLERK TO THE GOVERNORS, DIVISIONAL EDUCATION OFFICE, UPMINSTER COURT, HALL LANE, UPMINSTER. M 291

Classified Advertisements continued on Page 4

BRISTOL EDUCATION COMMITTEE.

COLLEGE OF TECHNOLOGY.

Principal: G. H. MOORE, M.Sc., F.P.S., F.R.I.C.

Applications are invited for the following posts available from 1st September next:—

(a) **LECTURER TO TEACH STRENGTH OF MATERIALS** in National Certificate and National Diploma Courses. Ability to teach Theory of Structures and/or other Mechanical or Aeronautical Engineering subjects an advantage.

(b) **GRADE B ASSISTANTS (2) TO TEACH MECHANICAL OR AERONAUTICAL ENGINEERING** subjects in National Certificate and National Diploma Courses.

(c) **GRADE B ASSISTANT TO TEACH MATHEMATICS** in Mechanical and Electrical National Certificate and National Diploma Courses.

(d) **GRADE B ASSISTANTS (2) TO TEACH TECHNOLOGY**, Practice and ancillary subjects in at least one of the following:—
(i) City and Guilds Machine Shop Engineering.
(ii) Press and Sheet Metal Work.
(iii) Welding, Gas and Electric.
(iv) Patternmaking and Foundry work.
To a suitably qualified person more advanced work in Higher National Production Courses will be available.

(e) **GRADE B ASSISTANT TO TEACH ELECTRICAL ENGINEERING** subjects in National Certificate and National Diploma Courses and in City and Guilds Courses.

(f) **GRADE A ASSISTANT TO TEACH MAINLY ELECTRICAL TRADE SUBJECTS** including Electrical Installation. Ability to assist with Radio and Communications Courses an advantage.

Burnham Technical Scale salaries for all posts at present as follows:—
Lecturer, £965 by £25 to £1065 per annum.
Grade B, £525 by £25 to £820 per annum.
Grade A, £450 by £18 to £725 per annum.

These salaries are under review and subject to confirmation the following are recommended from 1st October next:—
Lecturer, £1200 by £30 to £1350 per annum.
Grade B, £650 by £25 to £1025 per annum.
Grade A, £475 by £25 to £900 per annum.

Grade A and B Assistants receive additions for degree and training and increments for approved industrial experience.

Application forms and further particulars from REGISTRAR, COLLEGE OF TECHNOLOGY, UNITY STREET, BRISTOL, 1.

G. H. SYLVESTER,
Chief Education Officer M 292

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE.

BRIGHTON TECHNICAL COLLEGE.

Principal: G. E. WATTS, M.A., Ph.D.(Cantab.), B.Sc.(Lond.), F.R.I.C.

Required

GRADUATE LECTURER, OR ASSISTANT LECTURER IN CIVIL ENGINEERING to teach Civil Engineering subjects to Degree and Professional levels, with special reference to Hydraulics. Corporate membership of the Institution of Civil Engineers an advantage. Previous teaching and industrial or research experience desirable. Revised salary scales (subject to confirmation):—
Lecturer, £1200 by £30 to £1350 per annum.
Assistant Lecturer, £725 by £25 to £1100 per annum, with allowances for training and increments for approved industrial experience.

Further particulars and forms of application from the undersigned, to be returned to the PRINCIPAL, BRIGHTON TECHNICAL COLLEGE, BRIGHTON 7, as soon as possible.

W. G. STONE,
Director of Education.

54, Old Steine,
Brighton. M 290

UNIVERSITY OF NOTTINGHAM.

DEPARTMENT OF CIVIL ENGINEERING.

Applications are invited for appointments as **SENIOR RESEARCH ASSISTANTS.** Salary within the scale £650 by £50 to £1050 plus family allowance of £50 per annum for each child and superannuation benefits. Applicants should be graduates with practical experience. Conditions of appointment and Form of Application from the undersigned.

H. PICKBOURNE,
Registrar. M 288

NORTH THAMES GAS BOARD.

A SENIOR DRAUGHTSMAN, AGED 30-45, is required at the Chemical Products Works, Beckton, E.6. Candidates should have considerable experience in the design and layout of plant from flow diagrams, and in the preparation of schemes and contract specifications both for development and maintenance work. Starting salary will be within the range £750 to £900 per annum according to age, qualifications and experience. The successful candidate will be required to join the Staff Pension Scheme.

Applications, giving age and full particulars, to STAFF CONTROLLER, NORTH THAMES GAS BOARD, 30, KENSINGTON CHURCH STREET, W.8, quoting reference 666/324. M 286

APPOINTMENTS OPEN.

CONTRACTS ERECTION MANAGER, fully conversant with all aspects of erection of riveted and welded Gasholders, Tanks and Structural Work. Attractive salary, pension scheme, and car allowance. State age, and full details of past experience to: THE MANAGING DIRECTOR, ROBERT DEMPSTER & SONS, LTD., ELLAND, YORKS. M 232

SHIP DESIGN DRAUGHTSMAN required by Consulting Engineers in London. Applicants should have experience in the design of tugs and harbour craft. Pension scheme in operation.

Applications stating age, experience and salary expected, together with copies of recent testimonials should be sent to BOX No. 123, c/o CHARLES BARKER & SONS, LTD., GATEWAY HOUSE, LONDON, E.C.4. M 238

YOUNG ERECTING ENGINEER.

SULZER BROS. (LONDON) LTD.

REQUIRE A YOUNG ERECTING ENGINEER

for their Diesel Traction Department. Good general education and technical qualifications to ordinary but, preferably, higher national certificate level. Full apprenticeship on medium speed Diesel Engine and experience Erection Diesel Generator/Diesel Alternator sets essential. Position offers opportunity of training in Switzerland and promotion to keen and energetic man. Salary according to training and experience. Permanent appointment with staff privileges, including Life Assurance and Pension Scheme, after probationary period.—Write, confidentially, full details to MANAGER, DIESEL TRACTION DEPT., 31, BEDFORD SQUARE, W.C.1. M 252

LEVER BROTHERS, PORT SUNLIGHT, LIMITED.

If you have completed your National Service and have graduated in Engineering or hold similar qualifications, you may be interested in an appointment as a

TECHNICAL ASSISTANT to the Company's Power Engineer.

This position affords a valuable insight into problems arising in connection with the Company's power stations, large steam, electricity and water distribution systems, factory electrical plant and factory instrument services, and involves technical, administrative and cost control considerations. Operational and maintenance experience in the departments concerned will also be afforded, with a view to further promotion in the management structure.

The starting salary will vary according to experience, but, as an example, an applicant with post-graduate experience in engineering could expect a minimum starting salary of £700 p.a. There is provision for progressively increasing salary, an attractive pension scheme and additional progress payments.

Applications should be addressed to the—
Personnel Manager, Lever Brothers, Port Sunlight, Limited, Port Sunlight, Cheshire. M 255

FERODO, LIMITED, CHAPEL-EN-LE-FRITH, manufacturers of friction materials, invite applications for the following positions on the Test House Staff:—

1. DRAUGHTSMAN-DESIGNER to design new test machine and new devices for the measurement of friction thereon. Candidates must have drawing office experience in design and stress work and should have at least an Ordinary National Certificate, and preferably a Higher National Certificate in mechanical engineering or equivalent. Ref. No. 5033/1.

2. A TECHNICAL ASSISTANT to carry out investigations on the performance of test machines leading to the improvement of machines, testing procedures and methods of recording; also to organise special tests on proprietary brakes, clutches, overdrives, etc. Candidates should have at least an Ordinary National Certificate in Mechanical Engineering. Ref. No. 5033/2.

3. A TECHNICAL ASSISTANT to divide his energies, according to varying priority, between the two types of work specified above, i.e. part design and part experimental work. Candidates should have at least an Ordinary National Certificate in Mechanical Engineering. Ref. No. 5033/3.

These are staff positions at attractive salaries and carry a pension.—Applications, quoting the appropriate reference number, and giving full personal details including present salary, should be submitted in confidence to THE PERSONNEL MANAGER. M 221

HYDRAULICS. Glasgow firm specialising in Centrifugal Pumps of all sizes and types has vacancies for

SEVERAL MEN INTERESTED IN HYDRAULIC DESIGN AND DEVELOPMENT. Candidates should have training to University Degree or Technical College Diploma standard and have served an Engineering Apprenticeship; A.M.I.Mech.E. is an advantage.

Good salary depending on qualifications and experience. Pension Scheme available. As experience is gained, these openings offer excellent opportunities for advancement for a man with initiative able to translate his ideas into practical form.

Applications stating training, experience and salary expected, should be addressed in writing to 2061, WM. PORTEUS & CO., GLASGOW. M 265

MECHANICAL DRAUGHTSMEN

required, preferably with experience of Automobile Transmission Design, for work in connection with a new transmission system. The position is a progressive one. Salary in accordance with age and experience.

Housing accommodation available in the New Town within reasonable time for successful applicants.

Pension Scheme; Sports Club; Canteen facilities.
Write, or telephone Boxmoor 3800, giving full details of experience to

LABOUR MANAGER, ALFORD & ALDER (Engineers), LTD., MAYLANDS AVENUE, HEMEL HEMPSTEAD, HERTS. M 273

METHODS ENGINEERS. Well known large Engineering Company, engaged in batch production of precision equipment and Machines, requires several Methods Engineers at factories in the Birmingham area and in South Wales.

Applications are invited from Production Engineers with experience of modern Machine Shop practice, and who are interested in production cost reduction.

Posts will be permanent and pensionable. Good working conditions.

Applications should give details of training and experience, and should state salary required.—BOX M 262, Offices of ENGINEERING.

ENGINEER required to organise and control the work of a Service Department handling repairs and installation of Air Compressing equipment of all kinds, including ducted exhaust systems and similar sheet metal structures.

The work of the department is being progressively expanded, and this appointment represents a considerable opportunity for the right man.

Initial applications giving full details of age, qualifications and experience should be sent to THE WORKS MANAGER, THE AEROGRAPH COMPANY, LTD., LOWER SYDENHAM, LONDON, S.E.26. M 279

HEAD WRIGHTSON & CO., LTD.,

(McKee Iron and Steel Division) have several vacancies for

STRUCTURAL AND MECHANICAL DESIGNER DRAUGHTSMEN

(SENIOR AND JUNIOR) for work on the design of Materials Handling, Blast Furnace and Gas Cleaning Plants.

Applicants should preferably have experience of Iron and Steel Works Practice, but applications will be considered from draughtsmen wishing to take up this class of work.

Excellent working conditions; five-day week; pension scheme.—Applications, stating age, qualifications and salary required, to:—PERSONNEL MANAGER, REF. M.K./12, TEESDALE IRON WORKS, THORNABY-ON-TEES. M 158

A MANAGER/ENGINEER is required for Bulking installation in West Africa handling palm oil. Candidates must be of good education with very good administrative and organising abilities, experience in plant maintenance and control; preferably A.M.I.Mech.E., or equivalent. Age 26 to 33.

The post is one of responsibility and involves contact with local authorities, also control of African staff and their training when required. Practical experience should include operation and maintenance of steam boilers, engines and pumping plant and preferably of centrifuges, diesel engines and electrical equipment. Knowledge of Chemistry would be an advantage.

Commencing salary will be in accordance with qualifications and experience, but not less than £1500 per annum. In addition there are family allowances, free furnished accommodation, and free medical attention in Africa. First class passages provided. Tours in West Africa would be about 21 months each followed by leave on full pay. There is an initial kit allowance of £75. Contributory Pension Fund.

Apply giving full details of experience to BOX M 247, Offices of ENGINEERING.

DRAUGHTSMEN required for design and detail work on Mechanical Handling Plant for Gas Works-Power Stations, etc. Experience of this type of work comprising conveyors and associated structures, etc., desirable but not essential. Good salaries will be paid to suitable applicants with profit sharing bonus and superannuation schemes.—Applications in writing giving full particulars of age, experience and salary required to be forwarded to the CHIEF DRAUGHTSMAN, W. J. JENKINS & CO., LTD., 28, VICTORIA STREET, LONDON, S.W.1. M 224

DRAUGHTSMAN for Maintenance and Development of Seamless Steel Tube Plant. Heavy engineering and hydraulic experience desirable. Five-day week. Permanent pensionable position to suitable applicant. Special rate will be paid to man of high ability and qualifications.—Write stating full particulars to the CHIEF ENGINEER, STEWARTS & LLOYDS, LIMITED, BROMFORD TUBE WORKS, WHEELWRIGHT ROAD, ERDINGTON, BIRMINGHAM, 24. M 263

ENGINEERS AND DRAUGHTSMEN

THERMODYNAMIC, NUCLEAR ENERGY AND OTHER DEVELOPMENT

MERZ AND MCLELLAN, CONSULTING ENGINEERS, are recruiting high calibre men for their Development and Research and other Departments, where they are expanding their work on new developments, including advanced thermodynamic cycles for steam and gas turbines, and the use of nuclear energy for power production. Applications are invited from those with good technical qualifications including training in an appropriate field of engineering.

Vacancies are for engineers who have some years' experience on development or allied work in the same fields and also for junior engineers having these qualifications. Successful applicants would be given facilities, of which they would be expected to avail themselves, for learning the practice of the firm in power station design and construction.

In addition there are the following further vacancies for which applicants should have a sound mechanical or electrical engineering background. In the absence of the precise experience stated, applicants with equivalent experience might be considered.

(1) Senior and Junior Mechanical Engineers for the Atomic Energy, Boiler, General Engineering and the Test and Investigation Departments: good engineering degree and experience of design and operation of large boilers or of power station plant generally.

(2) Senior and Junior Draughtsmen for General Mechanical Engineering Department with O.N.C. or H.N.C. or O.N.D., and experience in power station layout and the design of all mechanical ancillary services.

(3) Senior and Junior Electrical Engineers for Power Station, General Engineering and Rotating Plant Departments. Good engineering degree and some practical experience of design, construction or operation of electrical plant desirable.

(4) Senior and Junior Draughtsmen for Electrical Engineering Department with O.N.C. or H.N.C. and preferably experience in layout of electrical plant and substations although not essential.

Wide prospects of advancement with attractive initial salary according to qualifications and ability. Five day week; pension scheme. Interesting work in congenial atmosphere. The vacancies mentioned above arise both in the Newcastle and Surrey Offices of the firm.

Apply quoting reference "G" giving age, full details of qualifications and experience to:—

MERZ and McLELLAN, CARLIOL HOUSE, NEWCASTLE-UPON-TYNE, 1 M289

or

MILBURN, MILBURN LANE, ESHER, SURREY.

Classified Advertisements continued on Page 121

Aluminium Wire is an excellent material for making all types of fastenings. It is available in alloys which provide many degrees of strength, hardness or ductility. Aluminium is light and a pound provides about three times as many fastenings as the same weight in other metals. Aluminium resists corrosion and is very durable; also, it does not stain other materials. Where aluminium is used as a building material, remember that the best fastenings for it are made from Aluminium Wire.

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AP 210/240*A*

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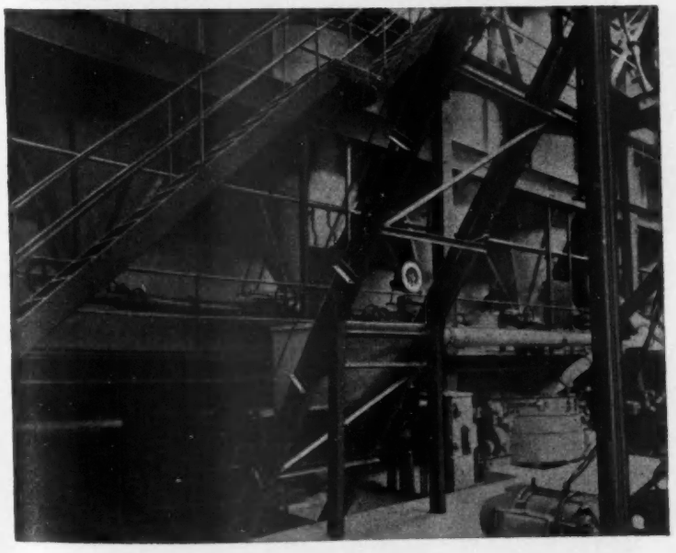

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Impedance measurements on a radial ultrasonic transducer developed for continuous cleaning processes.

End beyond vision

Whenever a new research project is initiated, none can foresee its end. Even applied research with limited objectives is likely to open up new avenues which invite exploration.

In the field of ultrasonics, modest beginnings have led to developments which few could have foretold. Mullard developed the first ultrasonic soldering iron for soldering aluminium. Now, from the same laboratory, have come other industrial applications which include ultrasonic drilling and ultrasonic cleaning of small engineered parts.

These new inventions will influence the production techniques of many industries, bringing benefits in the shape of better products, cheaper products, and greater efficiency. And as the applications of electronics extend in scope, Mullard Research may well have a part to play in the future of your own industry.

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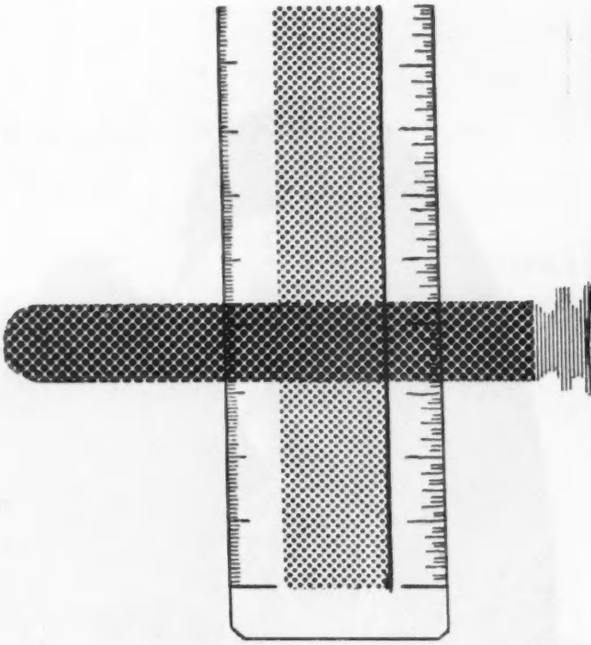

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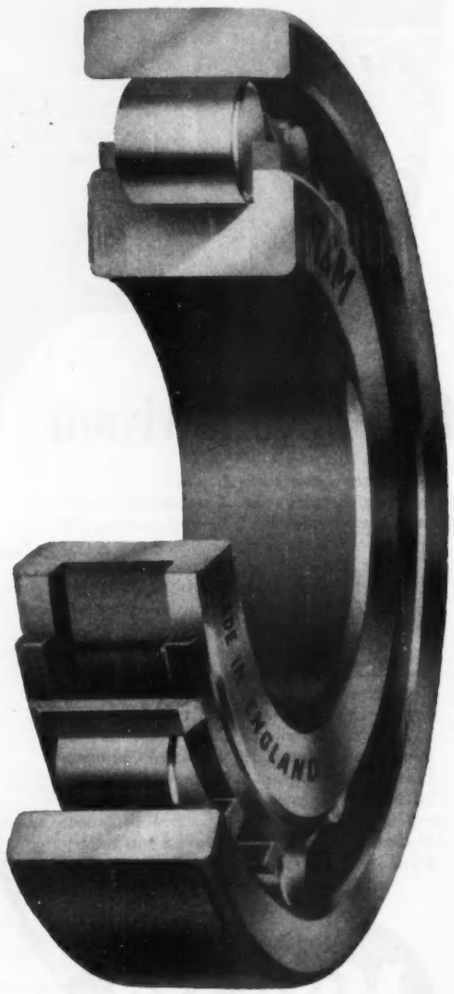

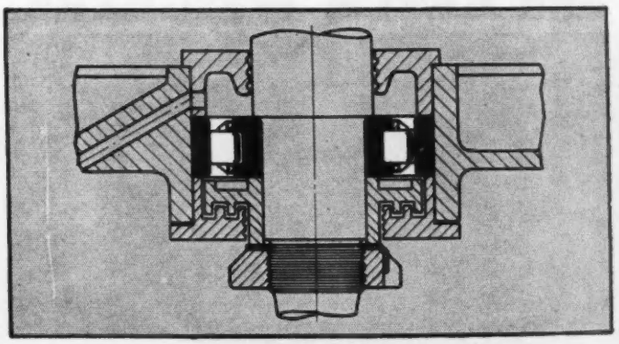

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Somewhere down the line

— is a busy little station

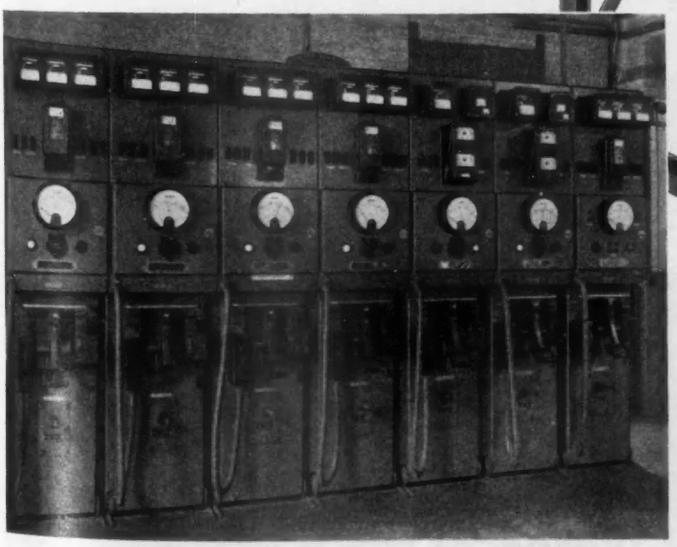
—a receiving depot for an established system of transport which brings to a growing community the food, raw materials and manufactured goods essential to its existence. This is one of many with a vital purpose.

Similarly, throughout the length and breadth of the land, are many " electric " substations like that shown below, distributing essential power supply to these same communities. Much of the switchgear is of " Ferguson Pailin " manufacture.

We are specialists in the SWITCHGEAR field, with a range of products stepping up from the medium voltage industrial type to the largest equipment in the " MAIN " category for power stations and transmission systems.

All receive the same expert attention throughout production—it is therefore well worth while to specify " Ferguson Pailin " when the need is for SWITCHGEAR.

Type OFS/IB3—11kV extensible ring-main equipment for indoor or outdoor service.



A typical type BV—11kV switchboard.

This ' FERGUSON PAILIN ' type BV—11 kV metalclad switchgear, with adequate protection against fire risks, is designed for extension to similar, or other, switch units/isolators as required. Circuit-breakers are interchangeable, each contained in its own truck, with easy access for inspection and maintenance purposes.

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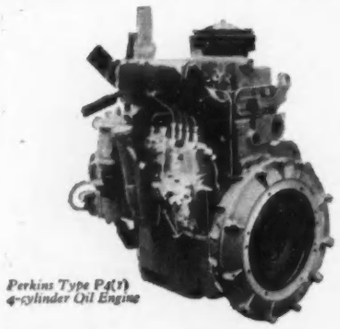
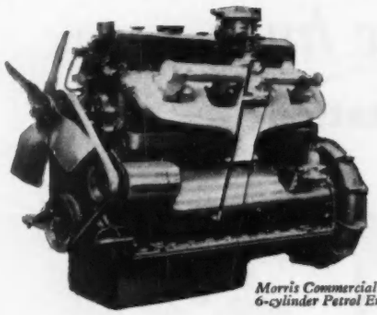
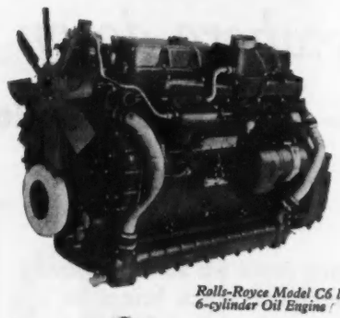


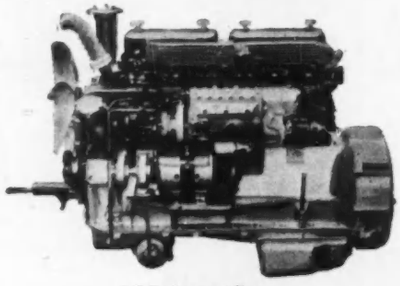
Perkins Type P4(T) 4-cylinder Oil Engine



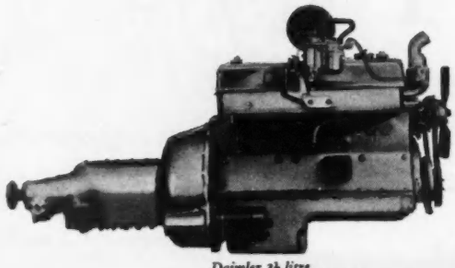
Morris Commercial S.A.E 6-cylinder Petrol Engine



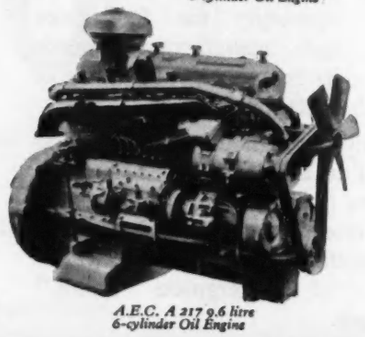
Rolls-Royce Model C6 NFL 104 6-cylinder Oil Engine



A.E.C. A 173 7.7 litre 6-cylinder Oil Engine

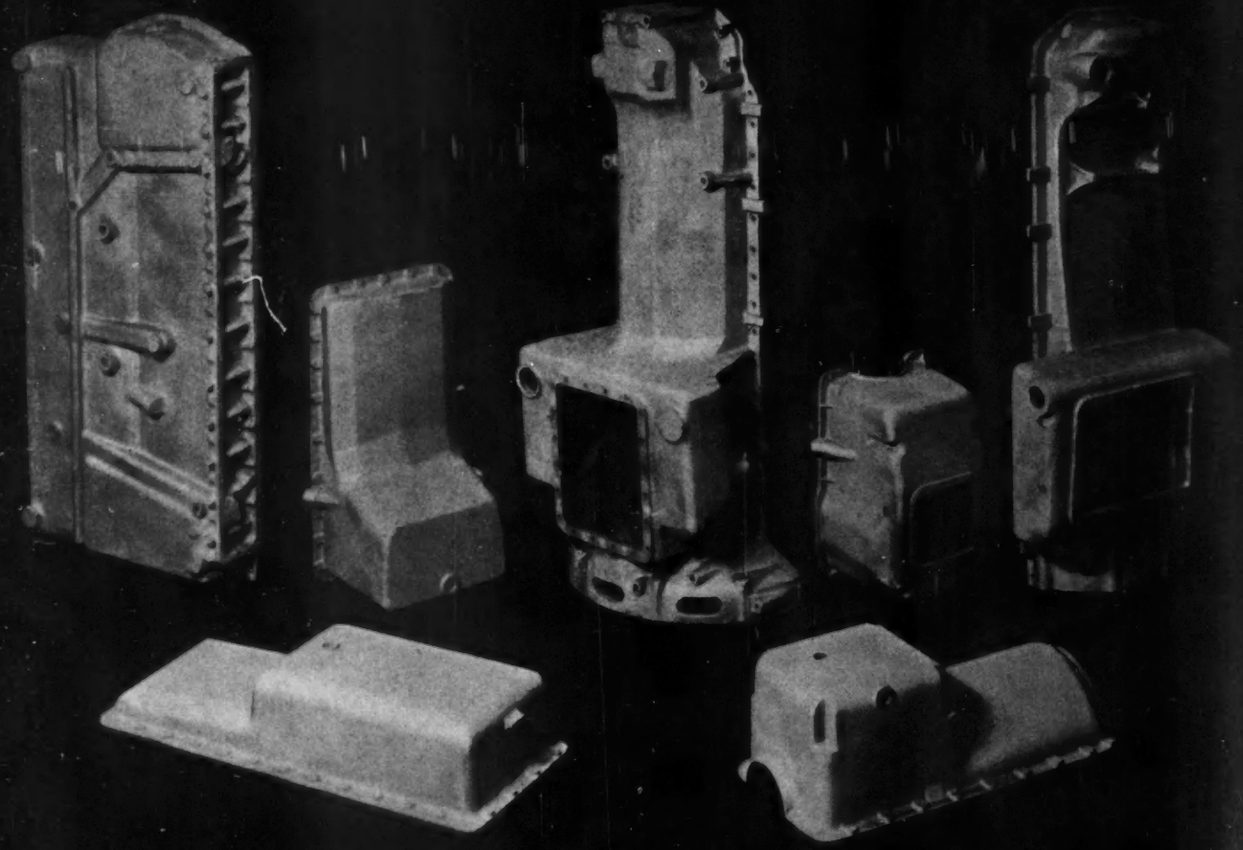


Daimler 2½ litre 6-cylinder Petrol Engine



A.E.C. A 217 9.6 litre 6-cylinder Oil Engine

Light Alloy Sumps for Engines



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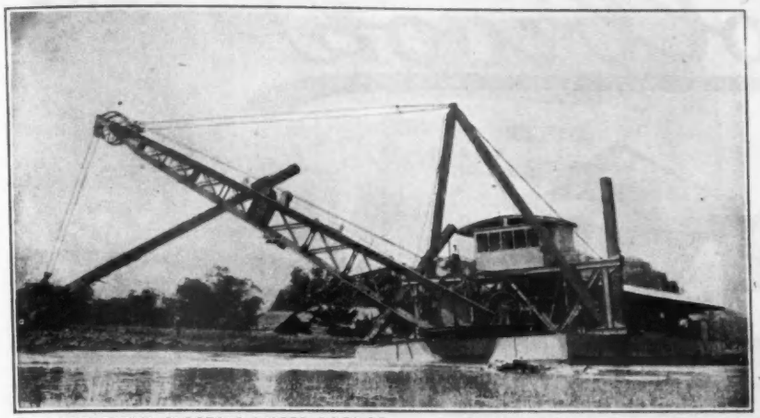

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OUTPUT: 148 cubic yards of silt and clay per hour dumped to a radius of 72 feet and a clear height of 20 feet.

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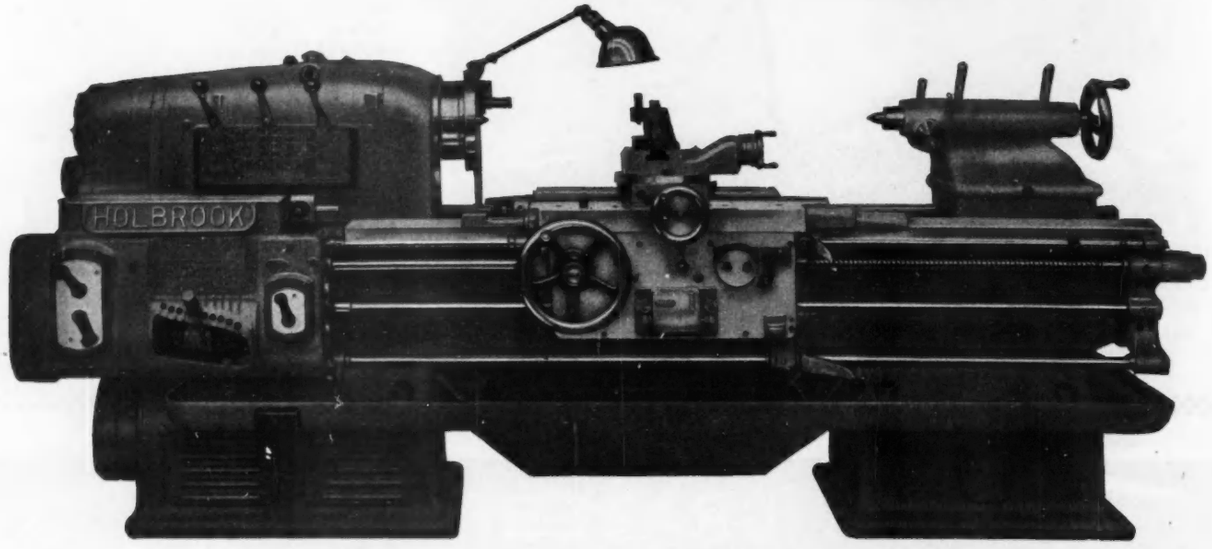

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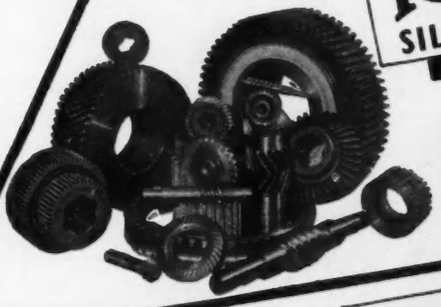

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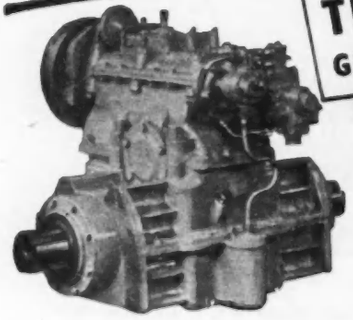

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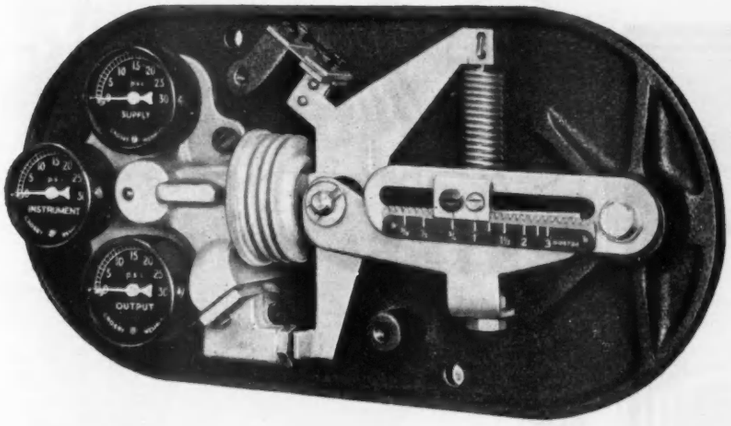
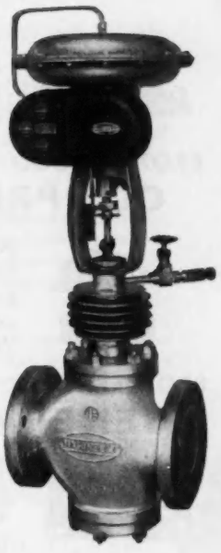


MASONEILAN CROSBY



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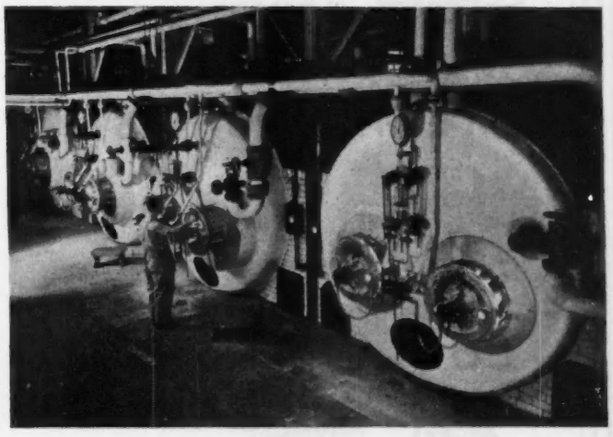
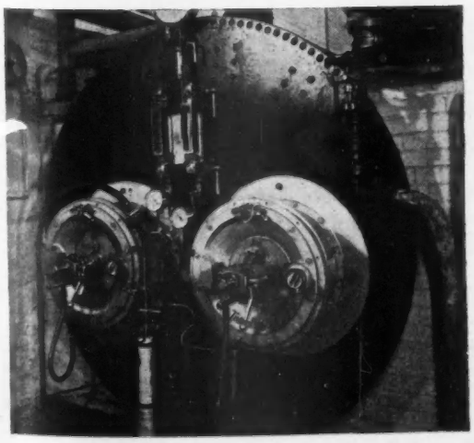
FOR MARINE AND INDUSTRIAL PURPOSES



Part of the installation at Messrs. Courage's Alton Brewery



Part of the installation at Winchester Hospital

The increasing use of Thornycroft Liquid Fuel Burning Equipment both for Marine and Industrial installations indicates appreciation of its special features—safety and simplicity in operation and a high standard of workmanship; up to 3,500 seconds fuel oils can be burned cleanly and efficiently.

For full particulars, write for a copy of publication SEB.89A in which will be found a questionnaire for completion and return to us.

JOHN I. THORNYCROFT & CO. LIMITED, WOOLSTON WORKS, SOUTHAMPTON

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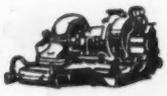

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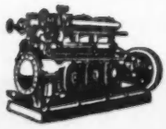

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Made to measure for special duties.

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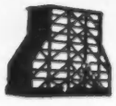

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Nearly 50 years' experience

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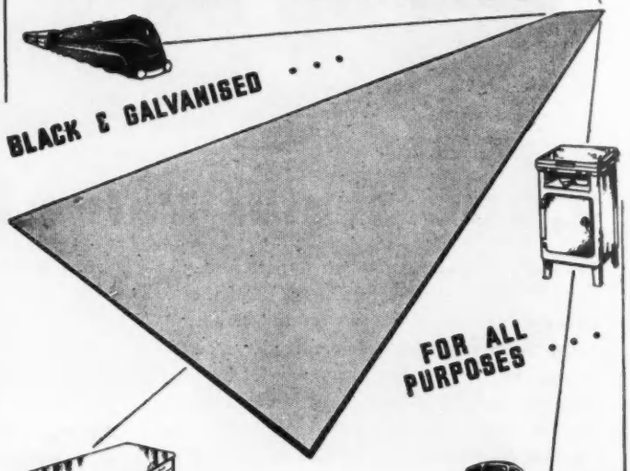

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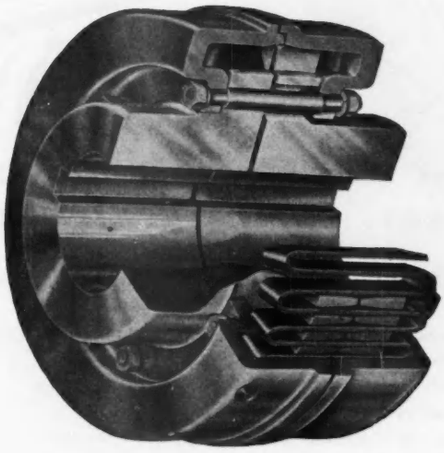

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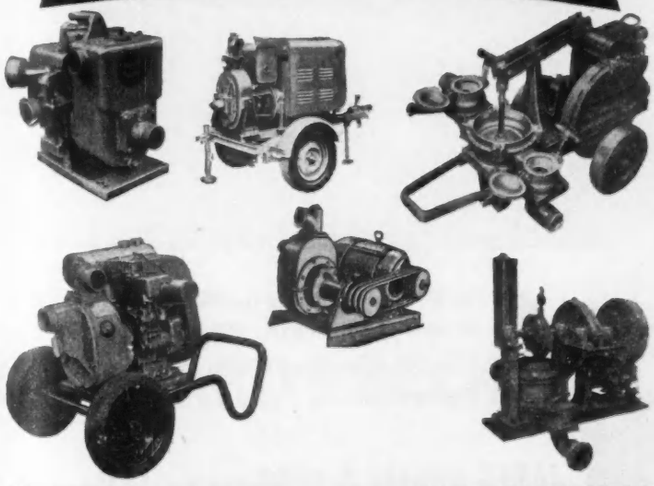

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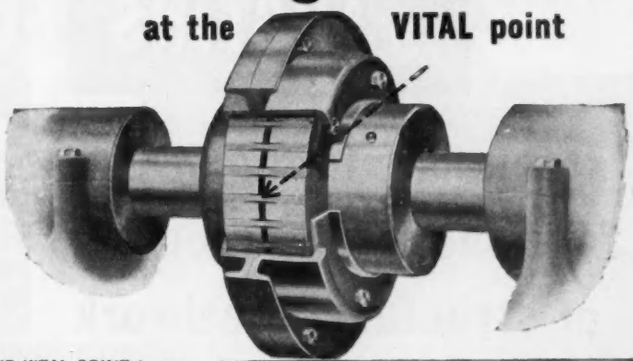

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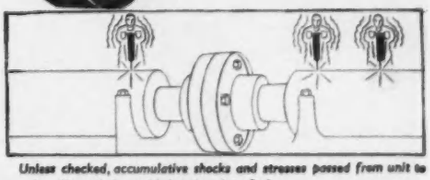

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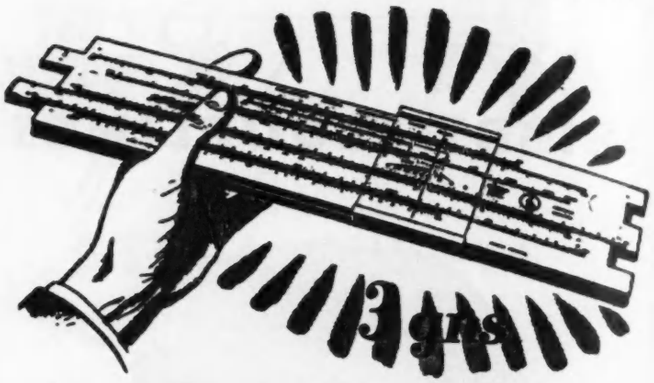

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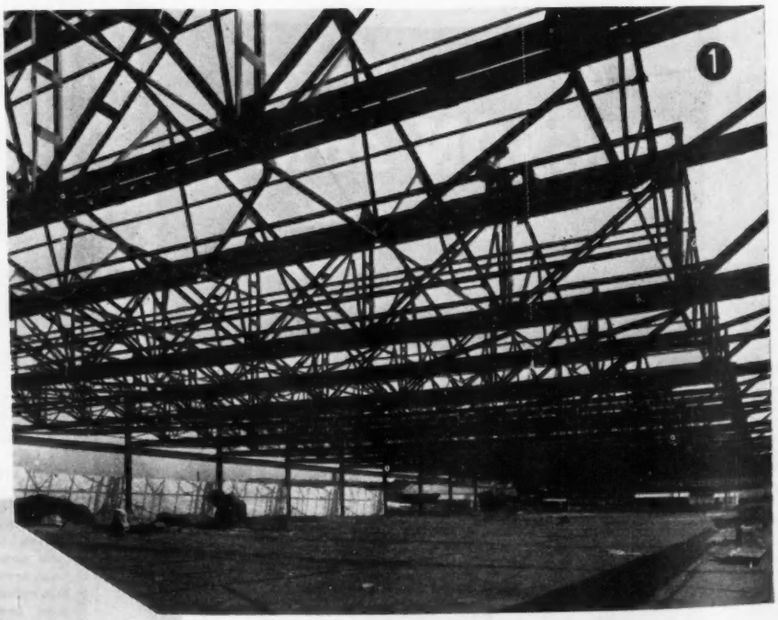

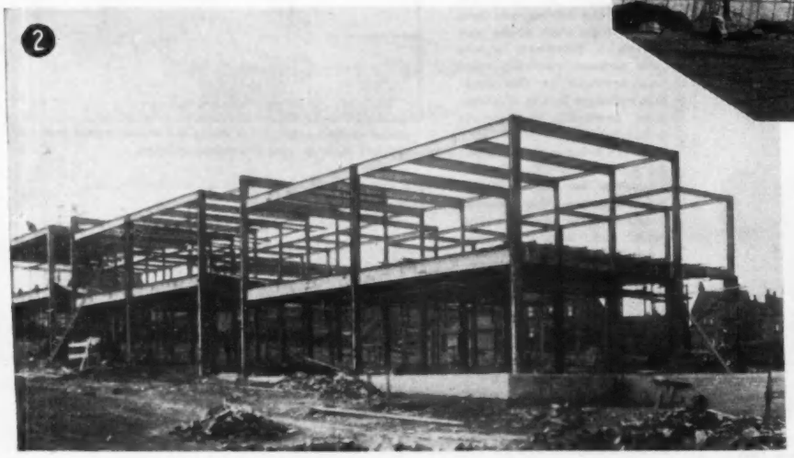

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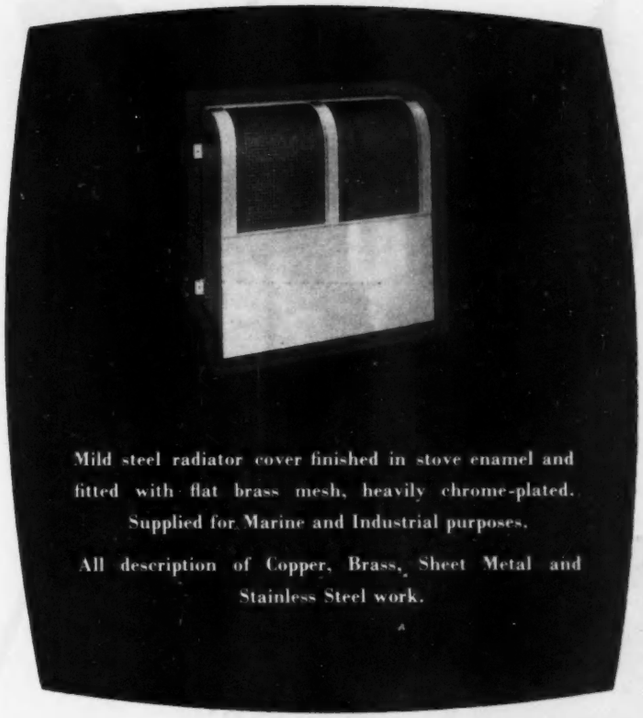

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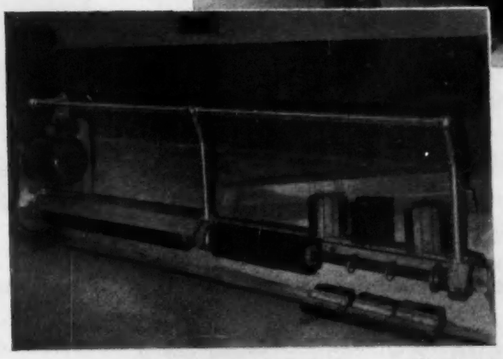

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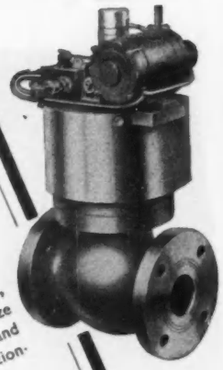

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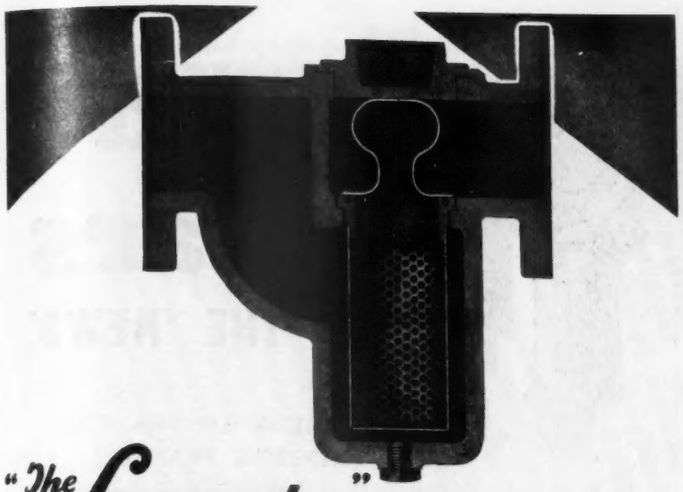

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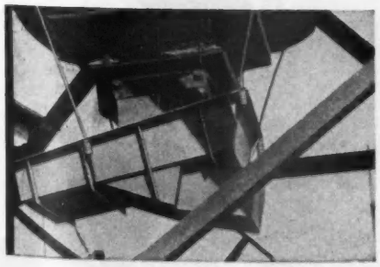

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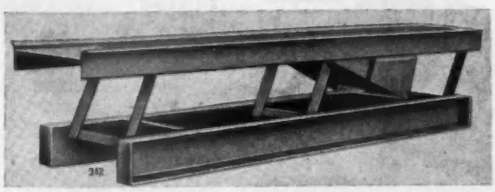

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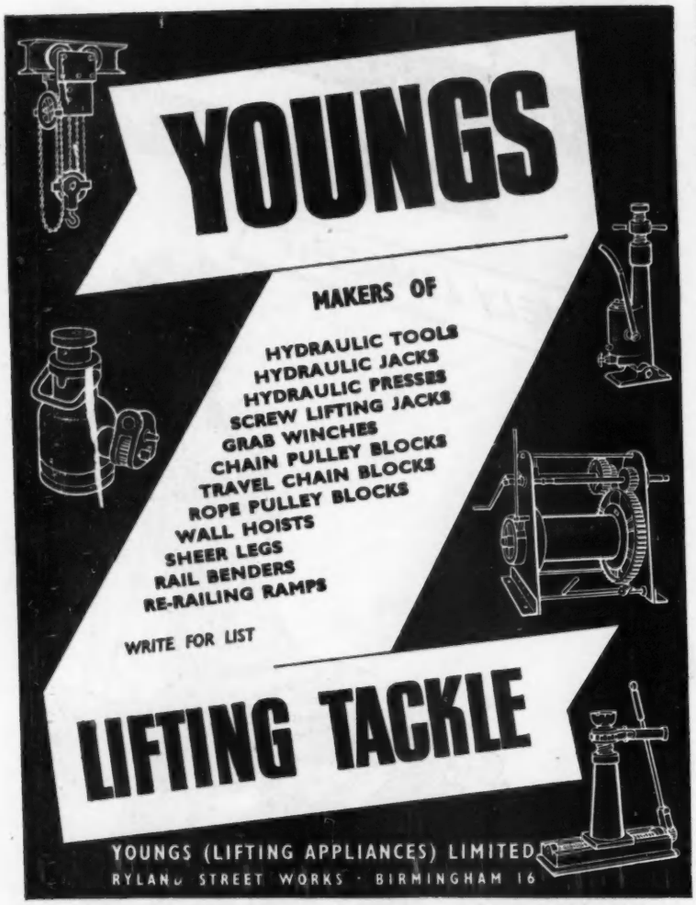

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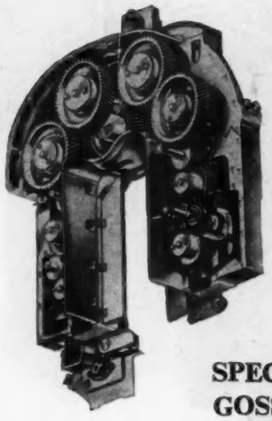

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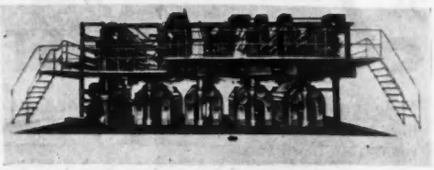

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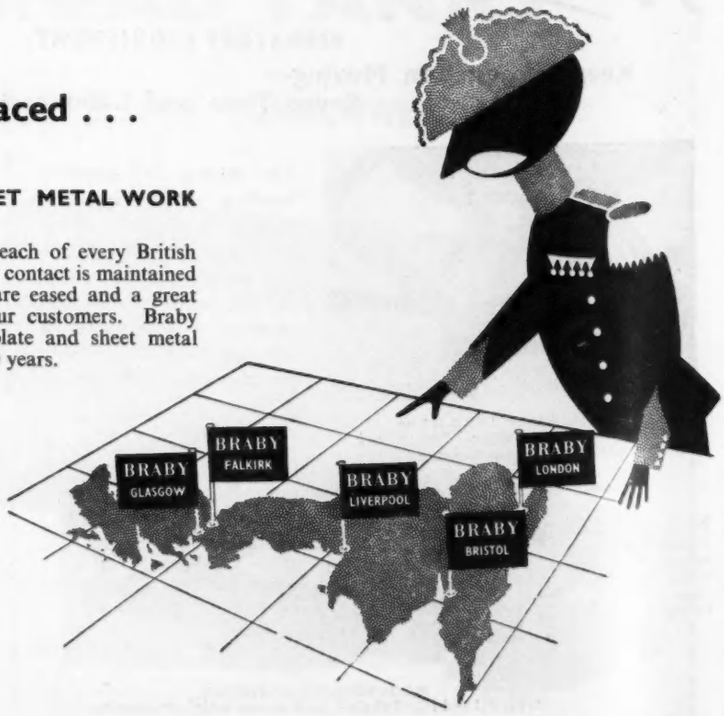

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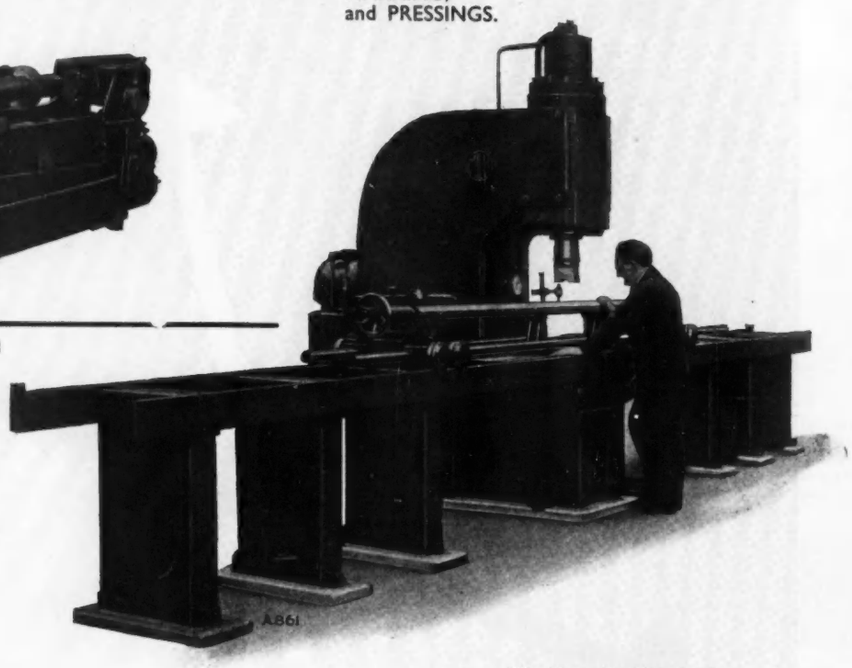

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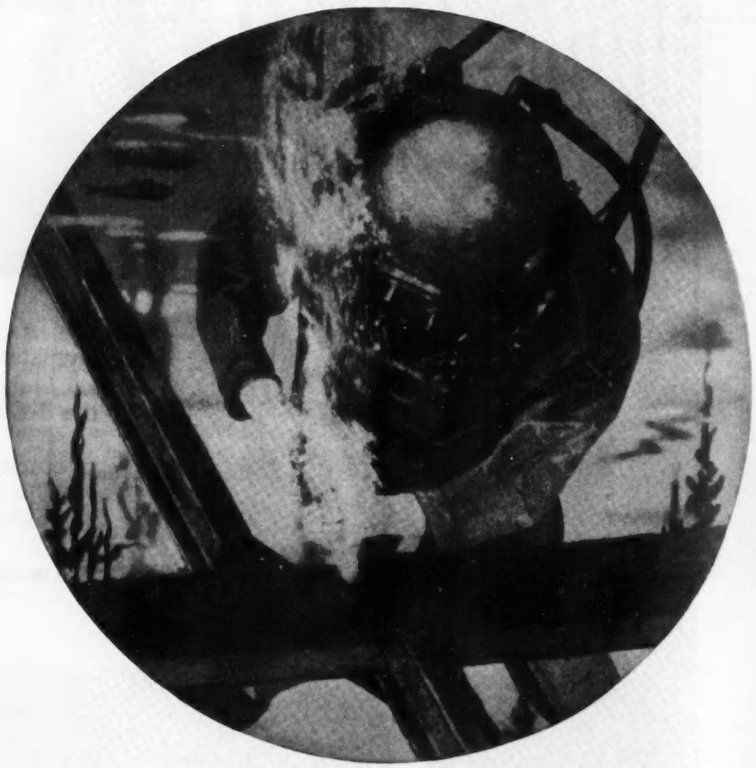

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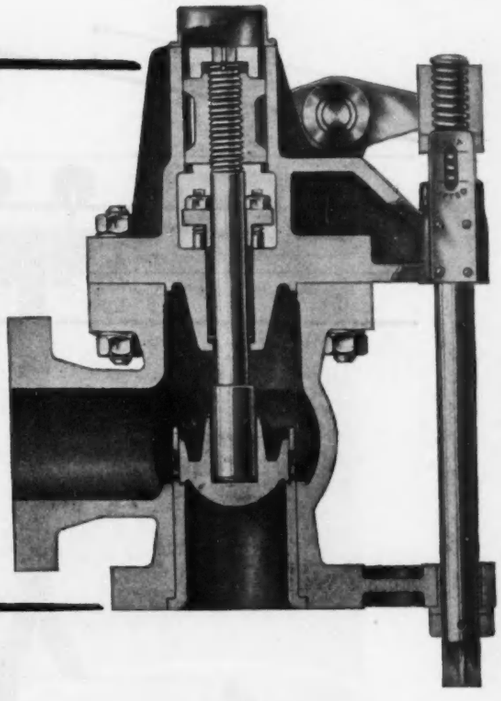

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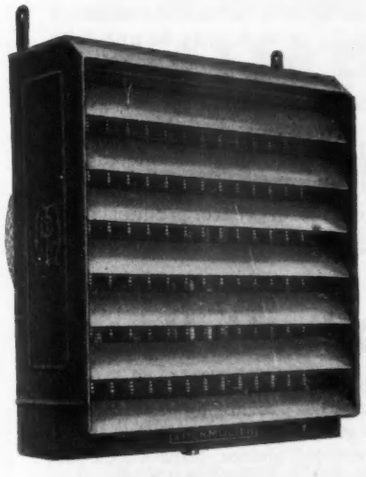

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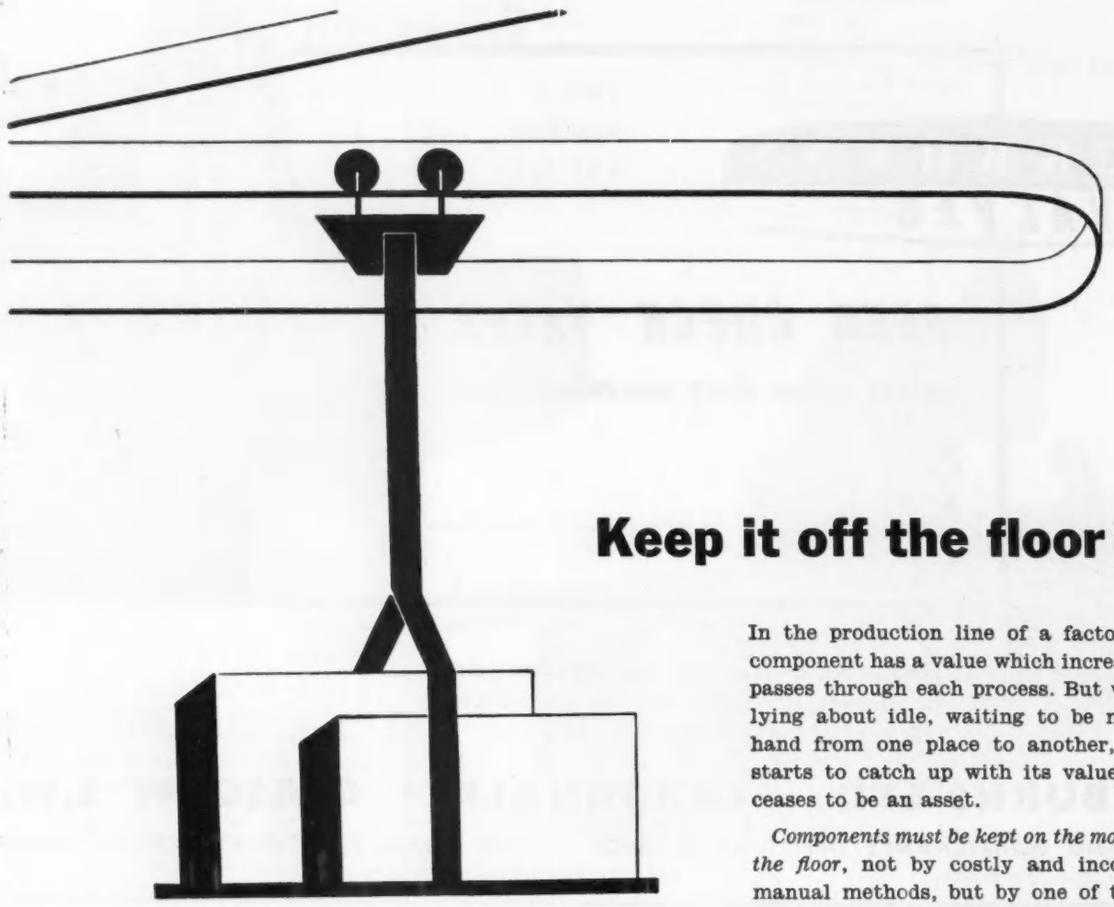

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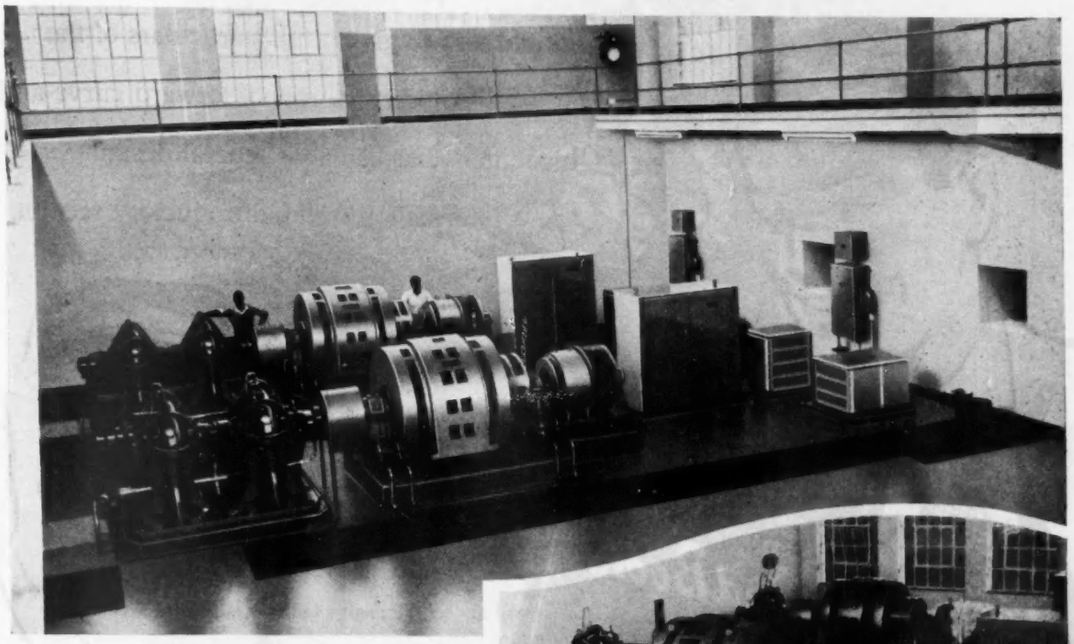

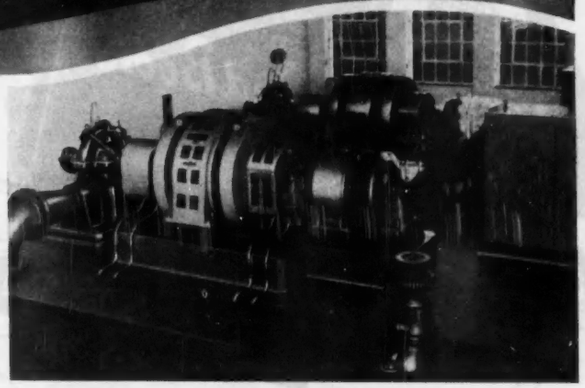

ALLEN PUMPING PLANT

FOR COMBINED WATER SUPPLY AND IRRIGATION SCHEME IN SOUTHERN RHODESIA

• • •

Water obtained from the Hunyani Poort dam, constructed on Lake McIlwaine, is supplied to the City of Salisbury, and to a general irrigation scheme on the Hunyani River.

Shown in the upper illustration is the plant at the main pumping station situated near the Hunyani Poort dam. It comprises two Allen 2-stage double-suction centrifugal pumps, each designed to deliver 400,000 Imperial gallons per hour to a booster station against a total head of 476 feet. The pumps are directly driven by 1,250-h.p. synchronous induction motors at a speed of 1,500 r.p.m.

The booster station plant at Warren Hills, shown in the lower picture, pumps the water to the municipal reservoir at Salisbury, to meet the City's demand of some 5,500,000 gallons per day. The distances between the two pumping stations, and from the booster station to the reservoir, are 81,000 feet and 33,600 feet respectively.

Each of the two booster pumping units comprises an Allen single-stage double-suction centrifugal pump, designed for a normal duty of 400,000 Imperial gallons per hour against 330 feet total head. These pumps are driven by 880-h.p. synchronous induction motors at a speed of 1,500 r.p.m.

The electricity supply for all the pump motors is 3,300 volts.

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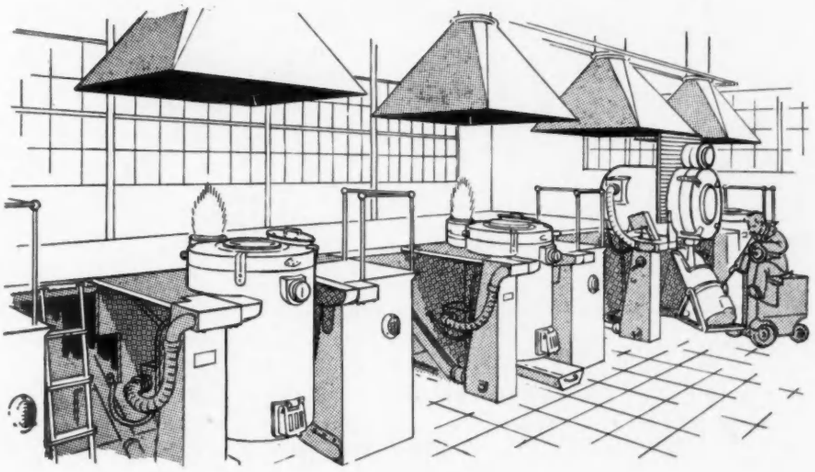

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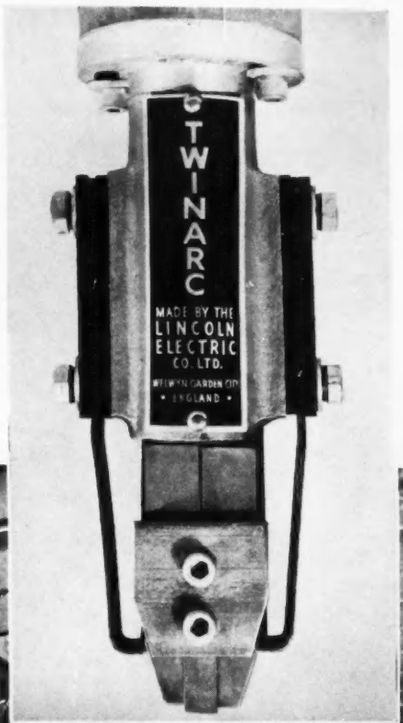
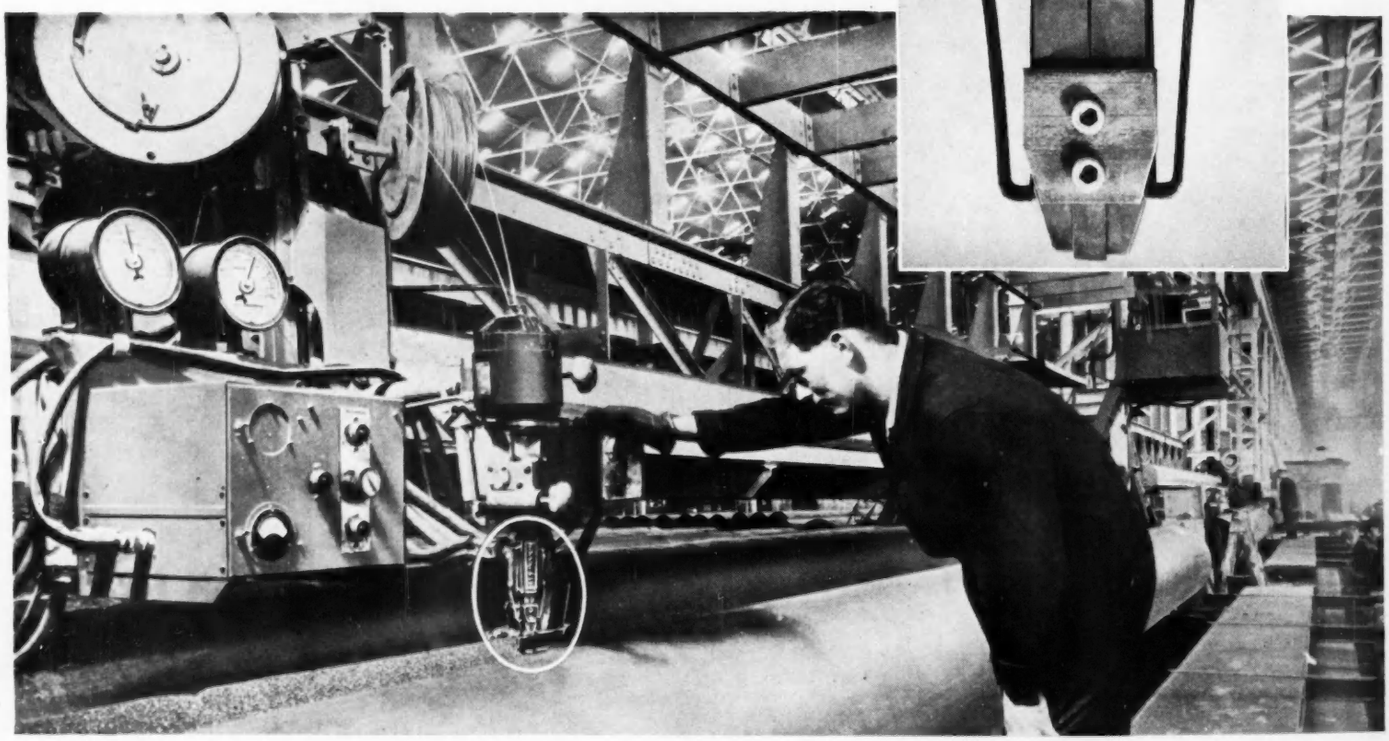
New Stockton Pipeworks uses Lincolnweld EXCLUSIVELY!

Throughout the new Stockton Pipeworks of Messrs. South Durham Steel and Iron Co. Ltd., the Welding equipment has been entirely supplied by Lincoln.





Opened by the President of the Board of Trade, this plant 'is the only one of its kind in the United Kingdom and Western Europe capable of manufacturing steel pipes to the length and diameter required to meet increasing world demand' (Middlesbrough Evening Gazette).

It has been equipped with three Lincolnweld twin-arc Fully Automatic Machines fitted with twin feeds for the electrodes, for automatic submerged-arc external welding, and with four Manual Lincolnweld M.L.2 automatic machines for internal welding by the Automatic Submerged-arc process. X-ray inspections are carried out at each stage of the pipe manufacture.

One of the first contracts secured—the £4,300,000 order for 75,000 tons of special pipe for transmitting natural gas over 250 miles of Canada—will be, in common with the whole of the South Durham Steel and Iron Company's pipe output from these works, exclusively Lincolnwelded.

LINCOLNWELD

Fully Automatic Submerged-Arc welding Equipment

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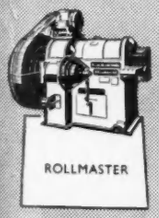
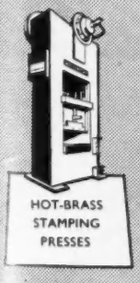

ROLLMASTER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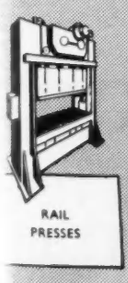
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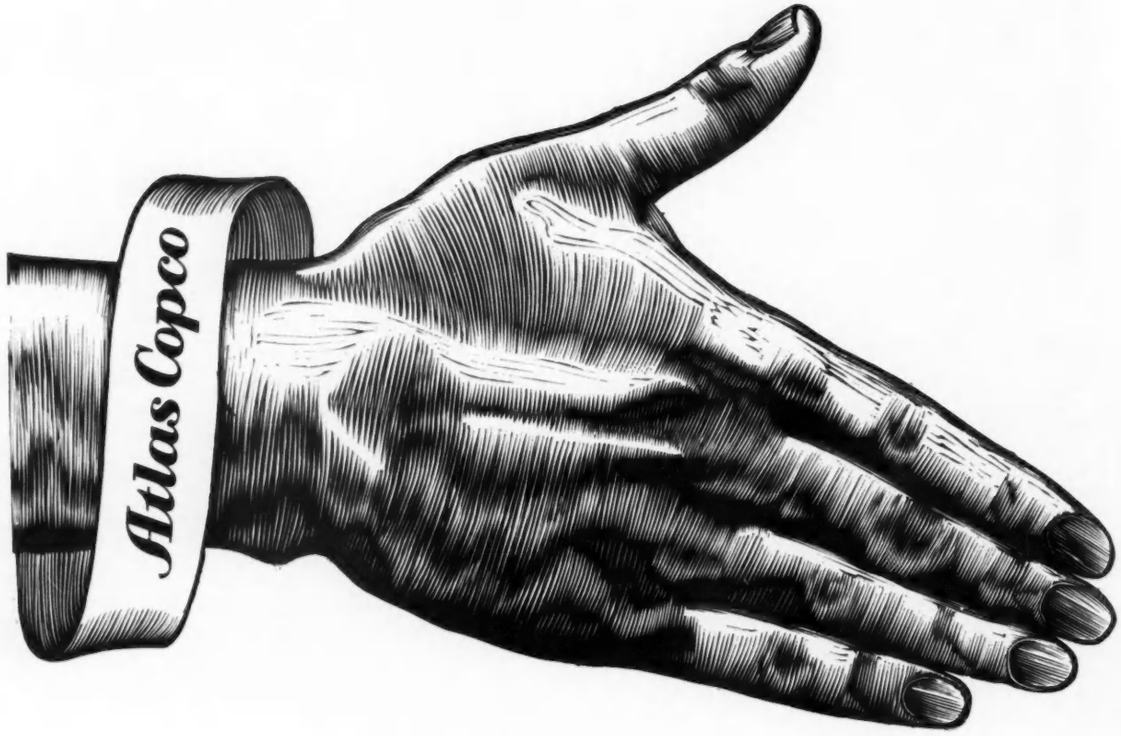


A great new partnership! Arpic Engineering—one of the foremost manufacturers of portable compressors—is now a part of the Atlas Copco Group of Companies. This will result in the

mutual pooling of production resources and technical ideas, and in the increase of existing world servicing facilities. Read on, about the advantages this will bring you....

Turn to next page

Now that Arpic are part of the Atlas Copco Group you will be able to choose a compressor from one of the biggest ranges of portables in the world

Atlas Copco manufacture a wide range of portable compressors, but not a complete range. This also applies to Arpic. However, the new *combined* range of portables is one of the most comprehensive in the world. From one source you can now choose portable compressors with air deliveries ranging from 36 to 550 cubic feet per minute. From the smallest to the largest, and all sizes in between. Portables for any operation, any climate and any altitude.

INCREASED PRODUCTION FACILITIES WILL SPEED DELIVERY

Now that Atlas Copco and Arpic are one, their various plants will be at the disposal of a common direction and a combined team of production engineers. This dovetailing of facilities will mean increased production, as well as earlier, more reliable delivery dates for all types of compressors. It will also speed maintenance work and the supply of spare parts.

The compressors formerly sold under the Arpic name will henceforth be known as Atlas Copco Compressors, *Type Arpic*. They will continue to be manufactured and assembled at the plant in Antwerp, one of the biggest and most modern of its type in the world, and at an up-to-date plant in Glasgow.

POOLING OF TECHNICAL IDEAS WILL IMPROVE THE DESIGN OF COMPRESSORS

Both companies gain much by the pooling of technical information. You can expect, in the future, positive improvements in the design of all types of portable compressors. Atlas Copco and Arpic will now have access to the many outstanding technical features both companies have developed over the years. The new range of portable compressors will be more than comprehensive. It promises to be the most advanced and most reliable in the world.

AN EXTENDED WORLD-WIDE SERVICE

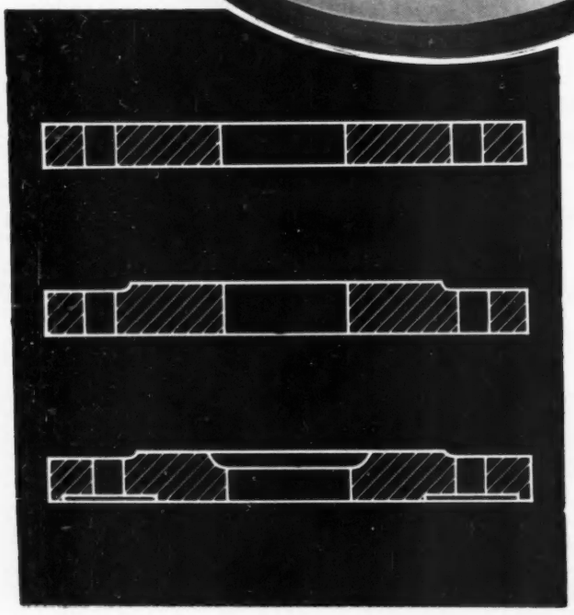
Arpic bring to Atlas Copco the services of something like 30 overseas depots. There will now be a total of 80 Atlas Copco companies or agents selling and servicing the new range of compressors all over the world. This reorientation greatly extends the on-the-spot service available to users.

The Atlas Copco Group of Companies

Compressed Air Engineers ★ Now incorporating the* ARPIC *Companies

For further details about the new range of compressors and the increased servicing facilities, write to your local Atlas Copco company or agent or to Atlas Copco AB, Stockholm 1, Sweden

MILD STEEL PLATE TYPE flanges



We are able to supply, from stock, a full range of Standard Plate Type Mild Steel Flanges for pressures ranging from 51 p.s.i. to 450 p.s.i.

Non-standard Flanges manufactured to specification.

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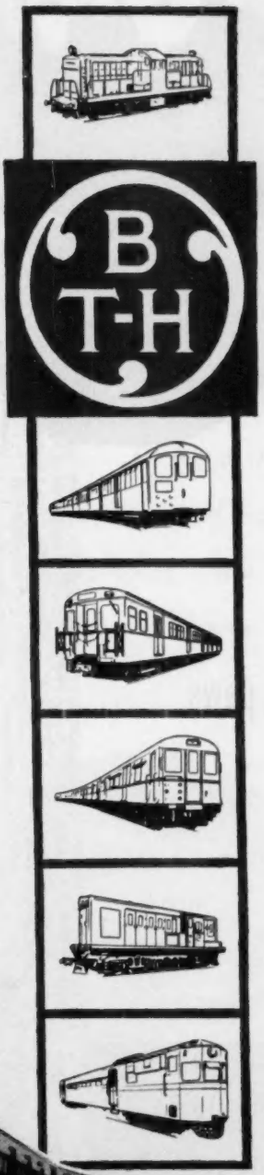
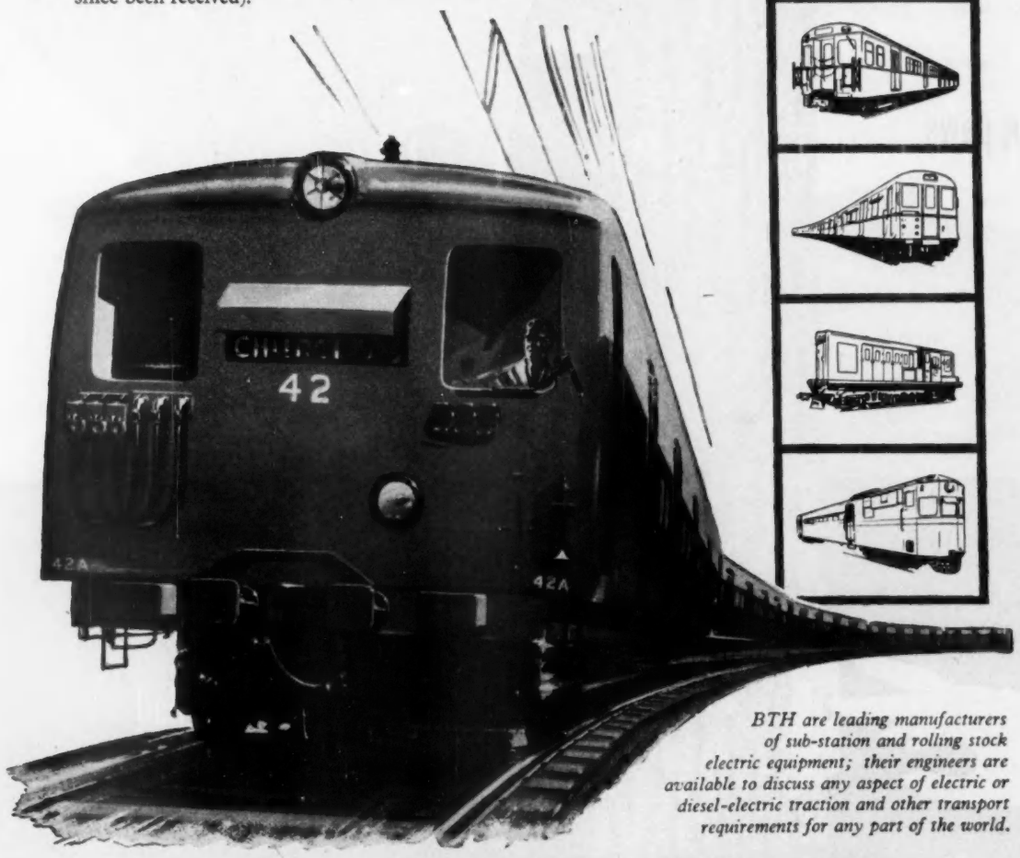


Associated from the first with progress in railway electrification, The British Thomson-Houston Co. Ltd. now has over half a century of electric traction experience in Great Britain and overseas. London's first tube trains were supplied by this Company, while the contract for the whole electrical sub-station and track-section cabin equipment for the extensions to the Liverpool Street-Shenfield electrification to Chelmsford and Southend (Victoria) has been awarded to BTH—the first order for inter-urban line electrification since the war.

As main contractors, BTH recently supplied ten 1,000 h.p. mixed-traffic diesel-electric locomotives for the New South Wales Government Railways, and provided traction control equipment for the 106 coaches of the new Toronto Subway, Canada (a repeat order for 34 control equipments has since been received).



BTH are leading manufacturers of sub-station and rolling stock electric equipment; their engineers are available to discuss any aspect of electric or diesel-electric traction and other transport requirements for any part of the world.

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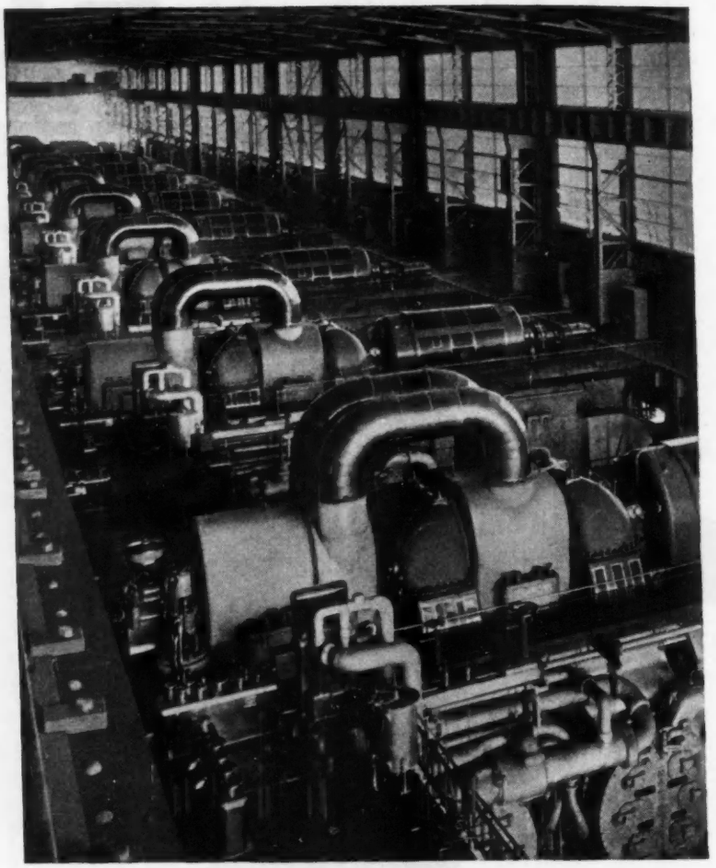
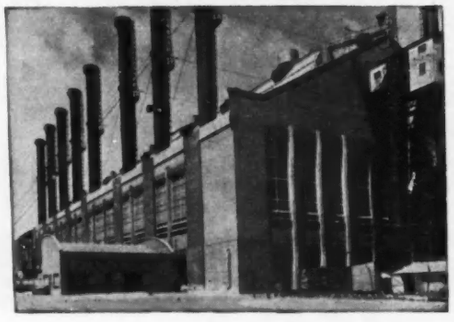
Largest power station built in South Africa since the war



The Vierfontein Power Station of the Electricity Supply Commission of South Africa, the largest to be built in the Union of South Africa since the war, will have an ultimate generating capacity of 360 MW

In May 1953 the first 'ENGLISH ELECTRIC'



30 MW turbo-alternator set was commissioned, and since then eight similar sets have been put into service. A tenth set is now being erected which will be followed by a further two sets now in course of manufacture.

CHEAP POWER

Standing on one of the world's most famous coalfields, the station is expected to produce power at the lowest cost in South Africa. The low cost of fuel combined with the high efficiency of 'ENGLISH ELECTRIC' plant provides an abundance of cheap power for the exploitation of another section of the greatest gold producing area in the world.

The turbines, which are the latest 'ENGLISH ELECTRIC' two-cylinder tandem compound type running at 3,000 r.p.m., are designed for steam conditions of 600 p.s.i.g., 825°F. at the turbine stop valve. The maximum economic rating of the generating sets is 30 MW.

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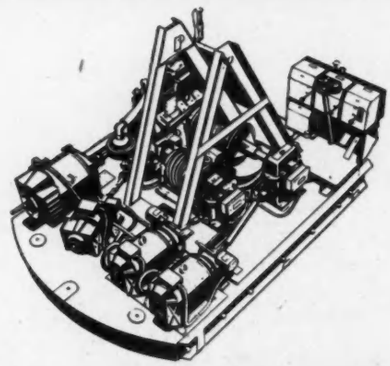

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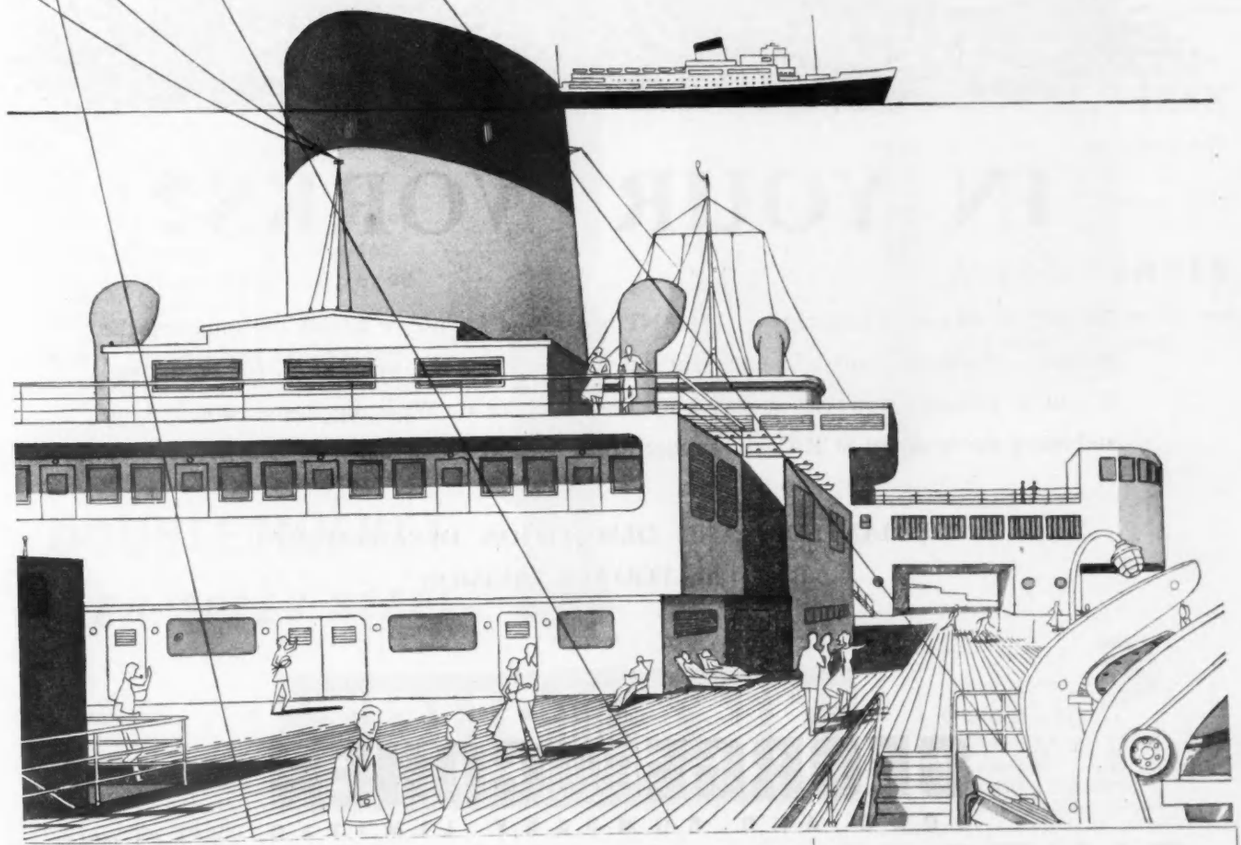

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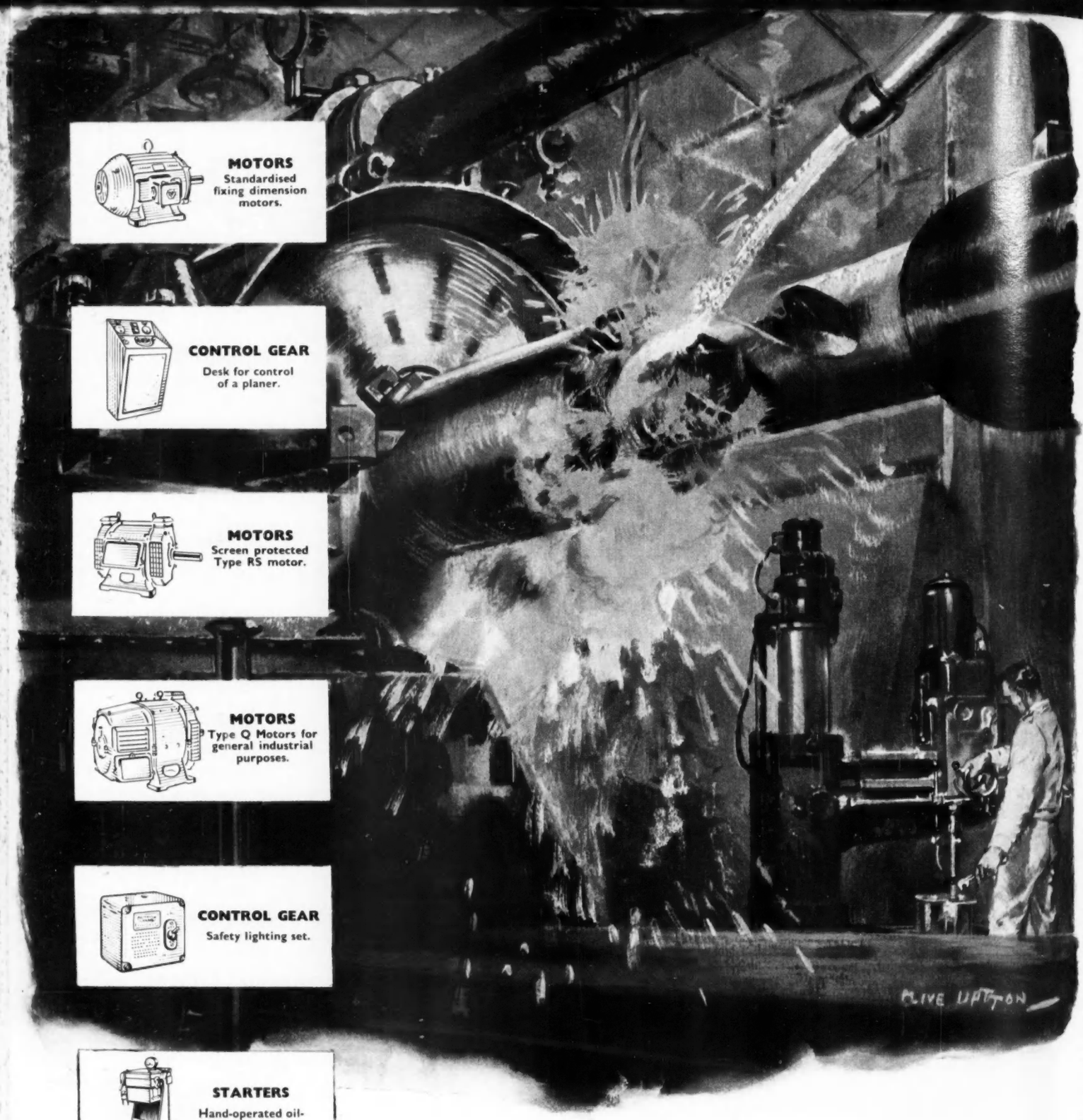

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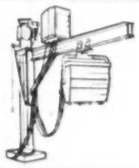

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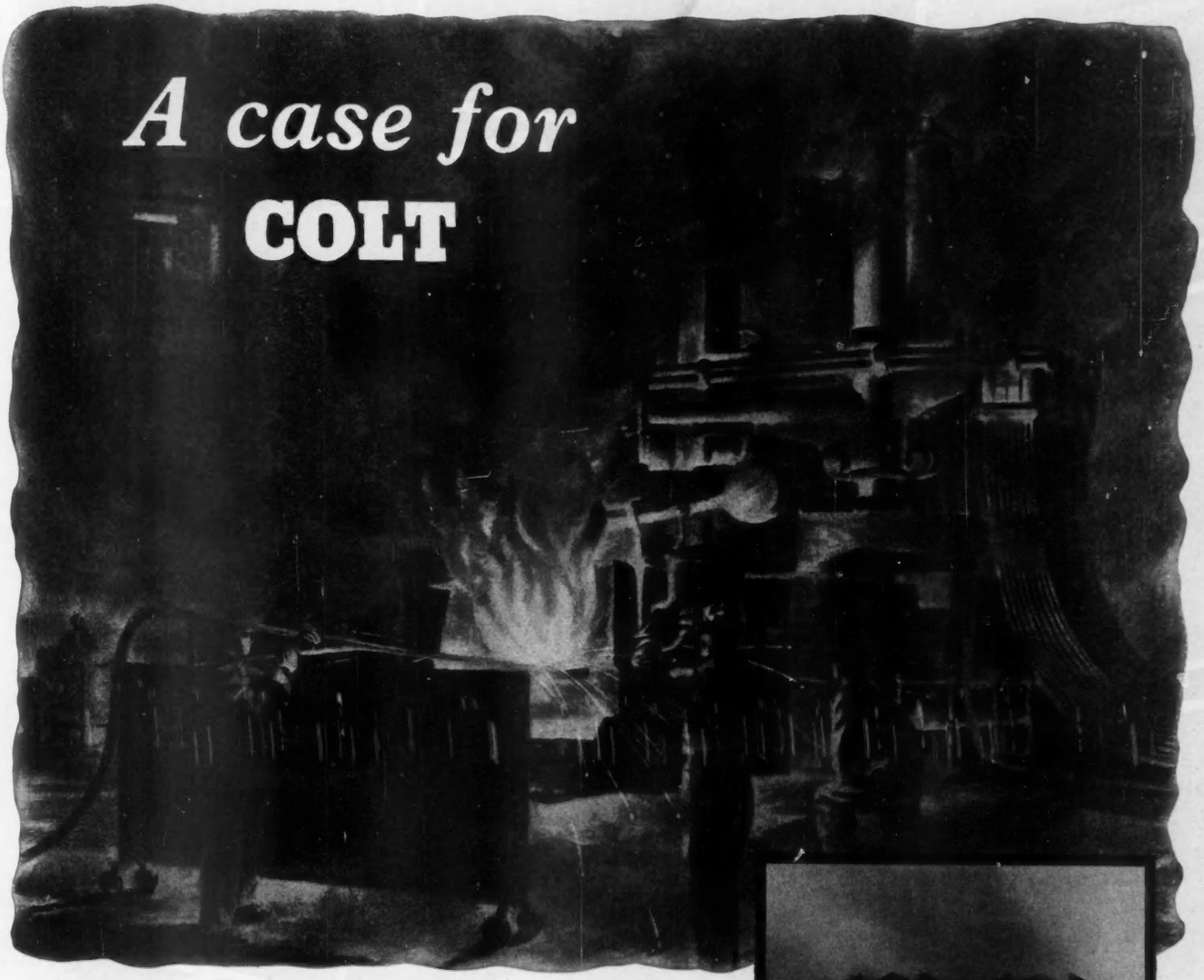

When oxygen blowing was introduced in these electric arc furnaces, smoke and heat filled the building down to floor level, making the furnace men's job difficult, and the crane driver's impossible. The problem here was to remove this smoke and excessive heat. After a careful survey Colt solved the problem by extracting through the Giant COLT Continuous S.R. Ventilators in the roof, replacement fresh air being provided by COLT Clear Opening Ventilators in the walls. This is one of eleven different installations we have surveyed and installed for K. & L. Steelfounders and Engineers Ltd., and they are but one of the 9,000 major industrial and commercial organisations with ventilation systems planned and installed by Colt.

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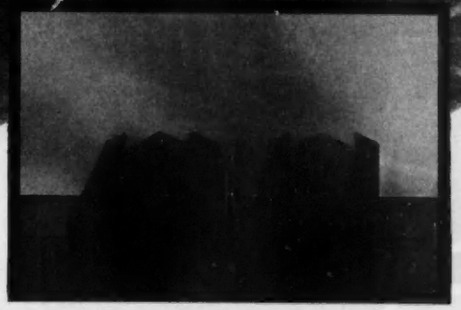

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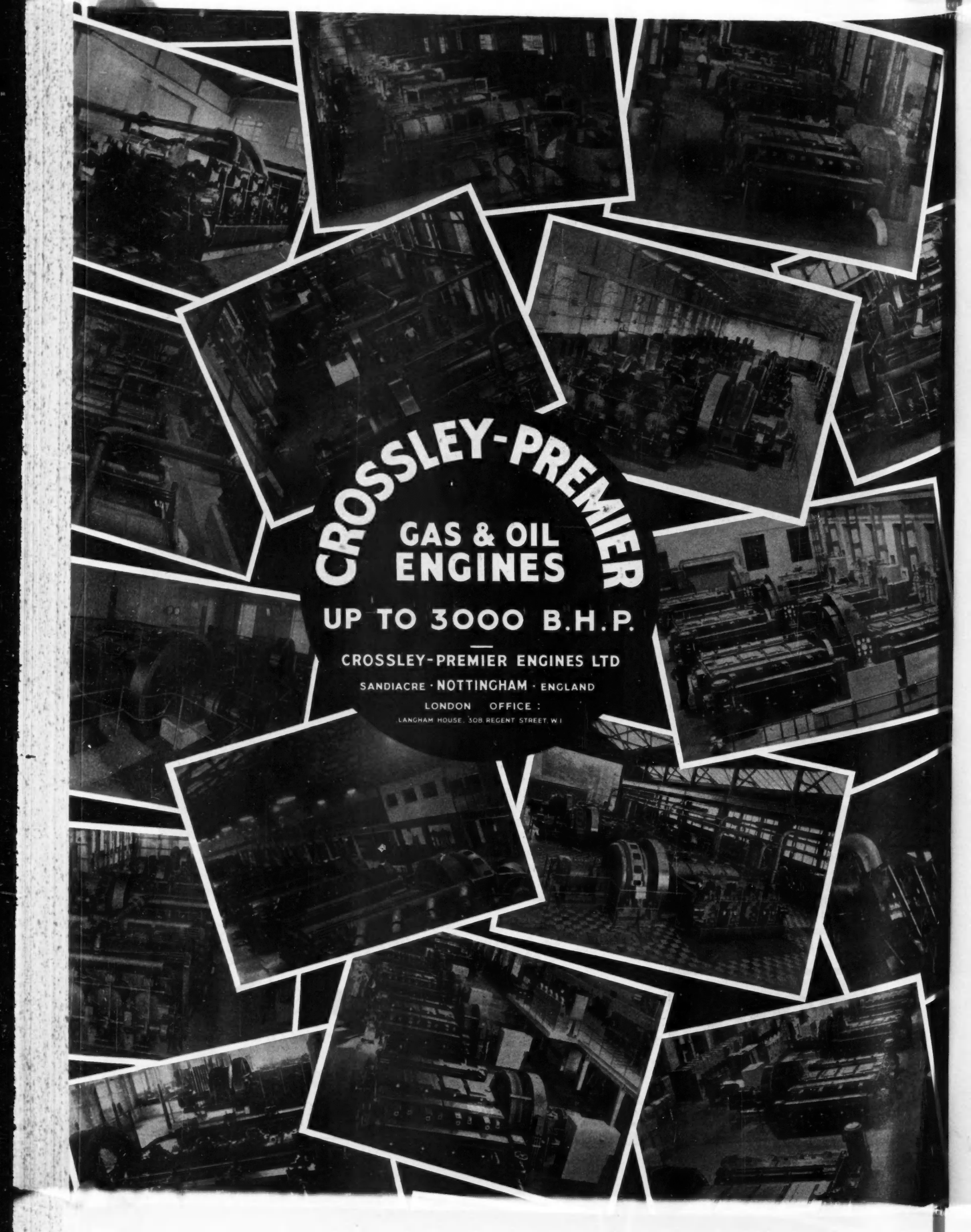
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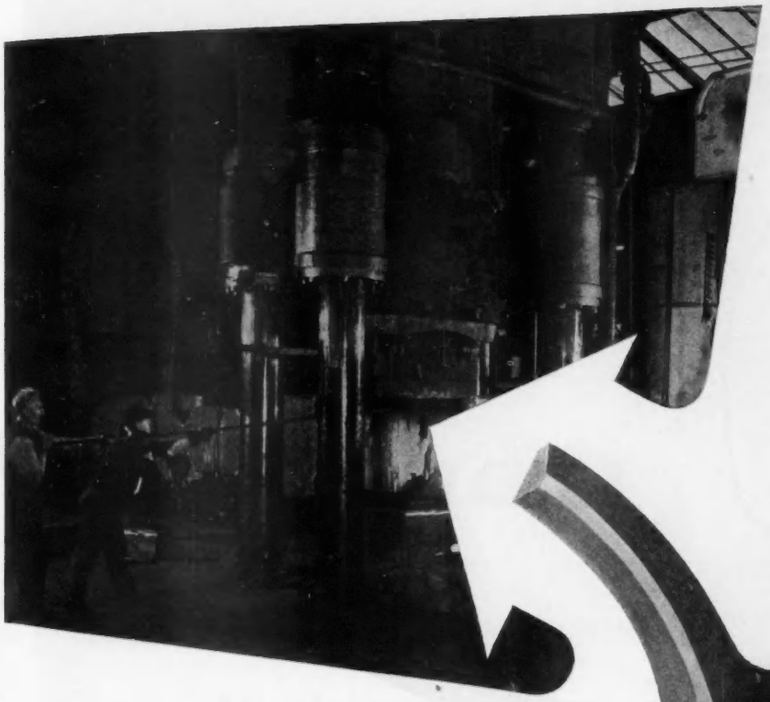

Marine and General Engineering

The forged steel sole piece illustrated, 19 ft. in length and weighing nearly 8 tons, was supplied recently for incorporation in a part fabricated ship sternframe.

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ELECTRICAL AND GENERAL STEEL FORGINGS

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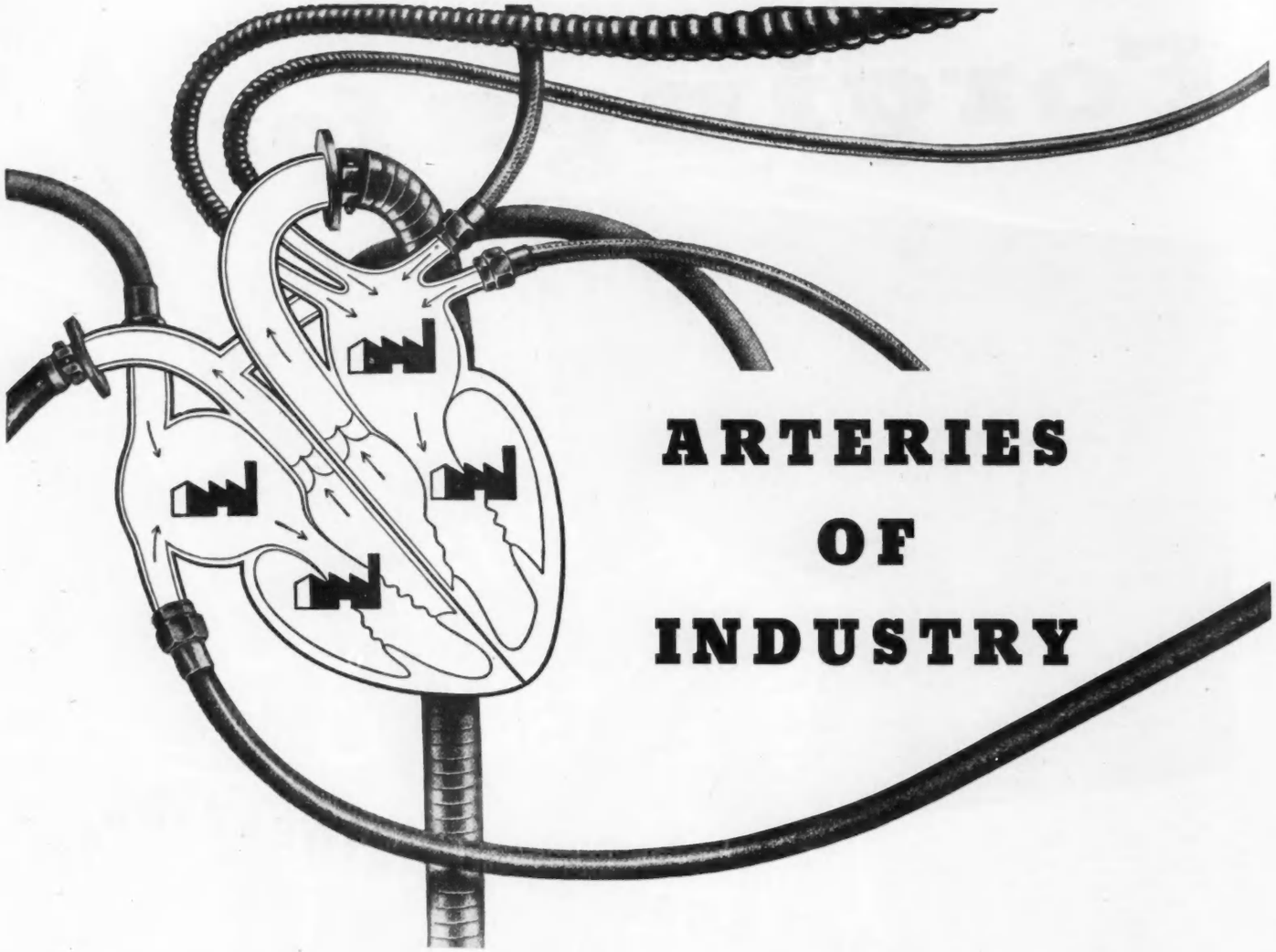
The DARLINGTON FORGE LTD
DARLINGTON



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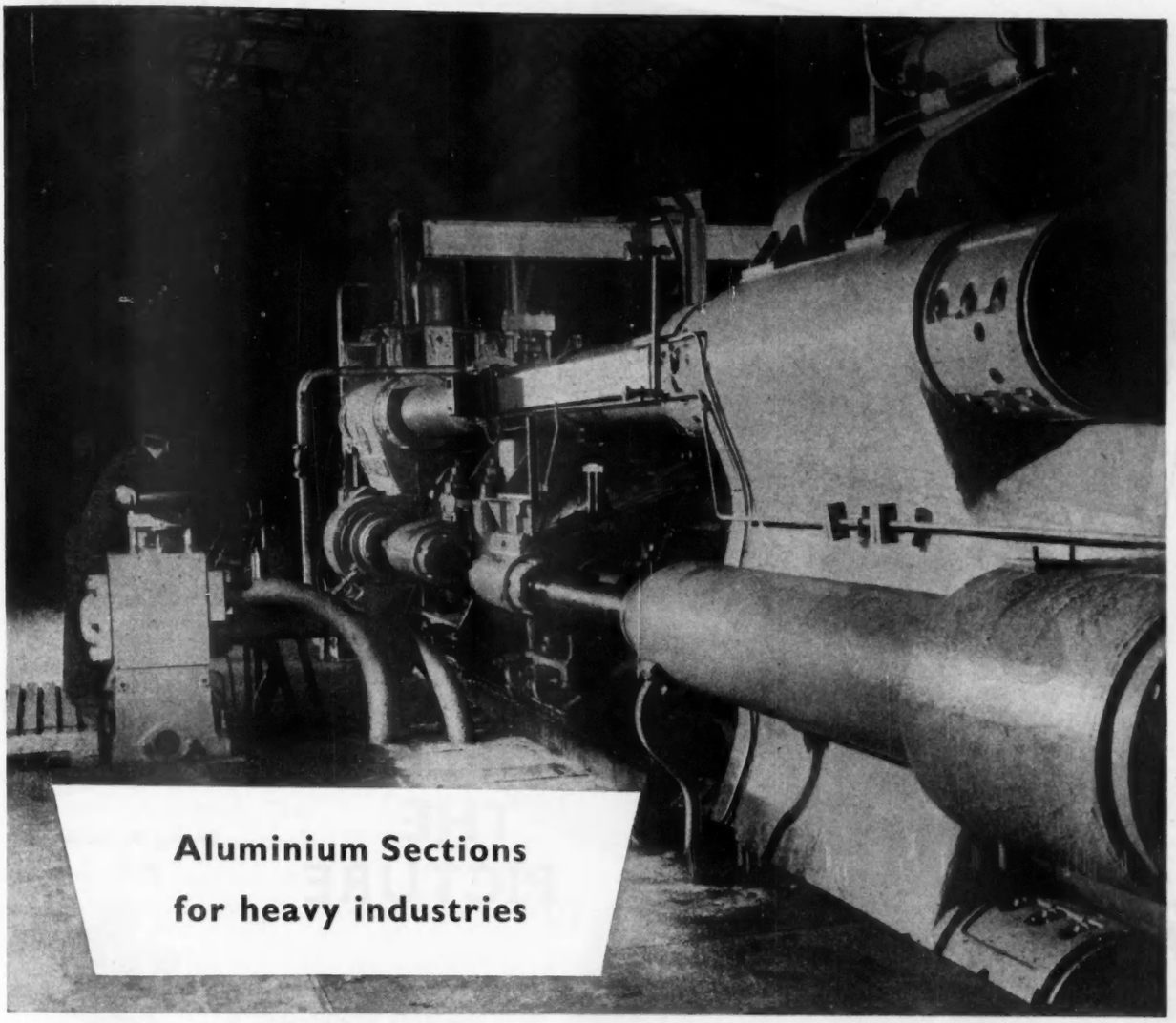

Two additional extrusion presses, one of 5,000 tons and the other of 3,500 tons, have been installed at the Latchford Locks Works of the British Aluminium Company. These presses represent an important extension to the extrusion capacity of the aluminium industry in this country. They will be used to produce a wide range of sections for the road transport, building, shipbuilding and structural and general engineering industries. Extrusions are available in sizes up to 13½" circum-circle and are specially designed to facilitate the economic use of aluminium in riveted or welded assemblies.

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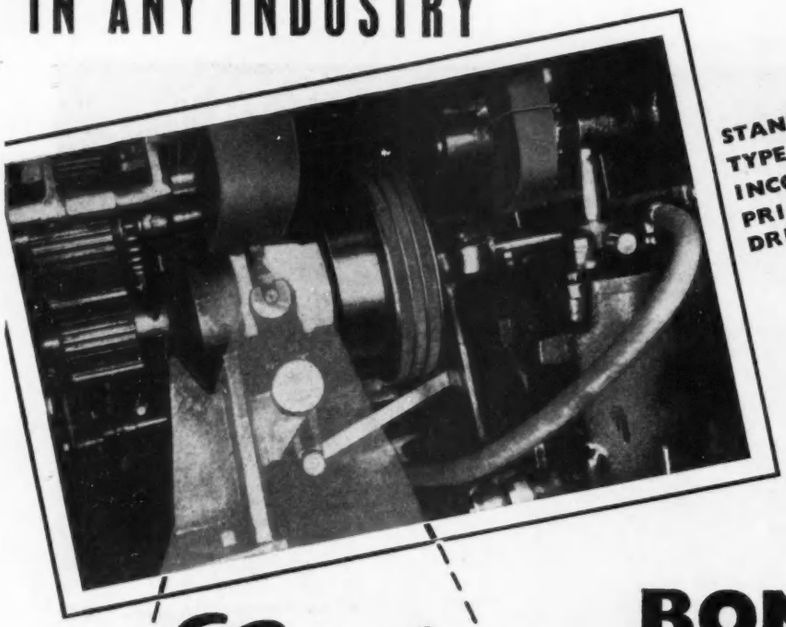

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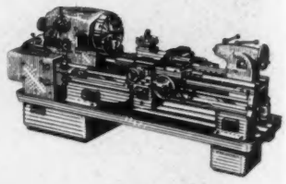
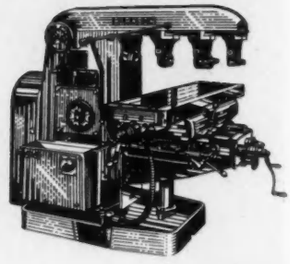
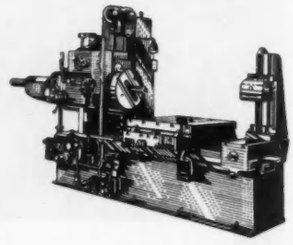


Centre Lathe



Milling Machine



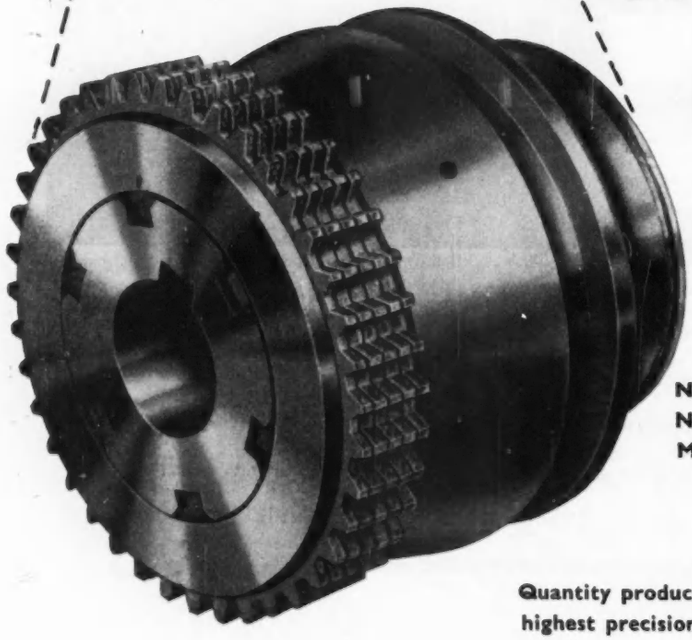
Boring & Turning Mill

Food Processing Machine

Crofts

BOM-L MULTIPLE-DISC CLUTCHES

COMPLETE THE PICTURE



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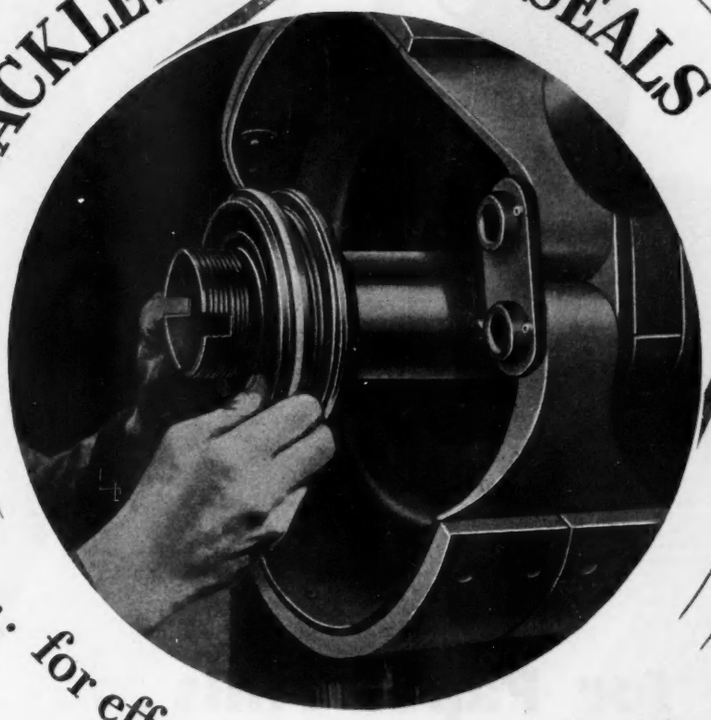
Teddington

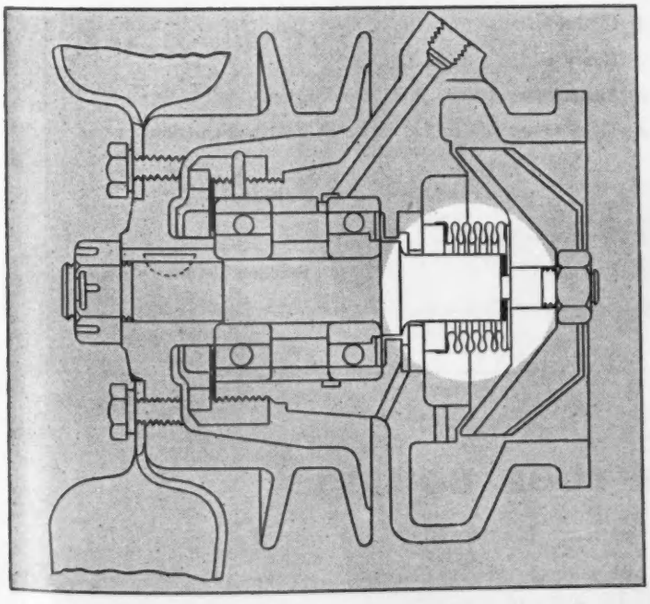
PACKLESS SHAFT SEALS



Photograph by courtesy of London Transport Executive

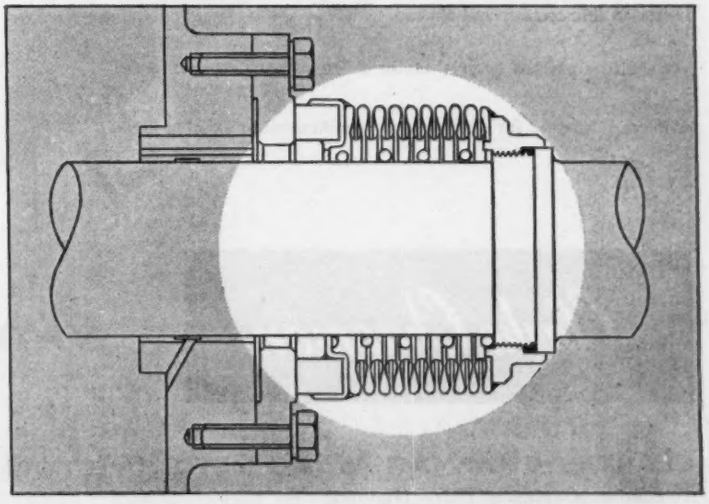
... for effective sealing against most liquids and gases

TEDDINGTON Shaft Seals are ideal for shafts running at speed. For example a 3½" dia. shaft running at 2000 R.P.M. in temperatures up to 300°F is quite normal. As peripheral speed of the rubbing surfaces is the deciding factor, they can be fitted to larger shafts running at lower speeds, or to smaller ones at high speeds. They will retain most liquids or vapours at pressures from 30-in. vacuum to 250 lbs. per sq. in., and are unaffected by continuous or intermittent running, or reversing.



Write for leaflet BTC62

The British Thermostat Company are the largest manufacturers of metallic bellows in Europe and, during the last 25 years, have acquired unique experience in the design and application of metallic bellows and packless shaft seals. Write for Leaflets NS.5 and NS.33.



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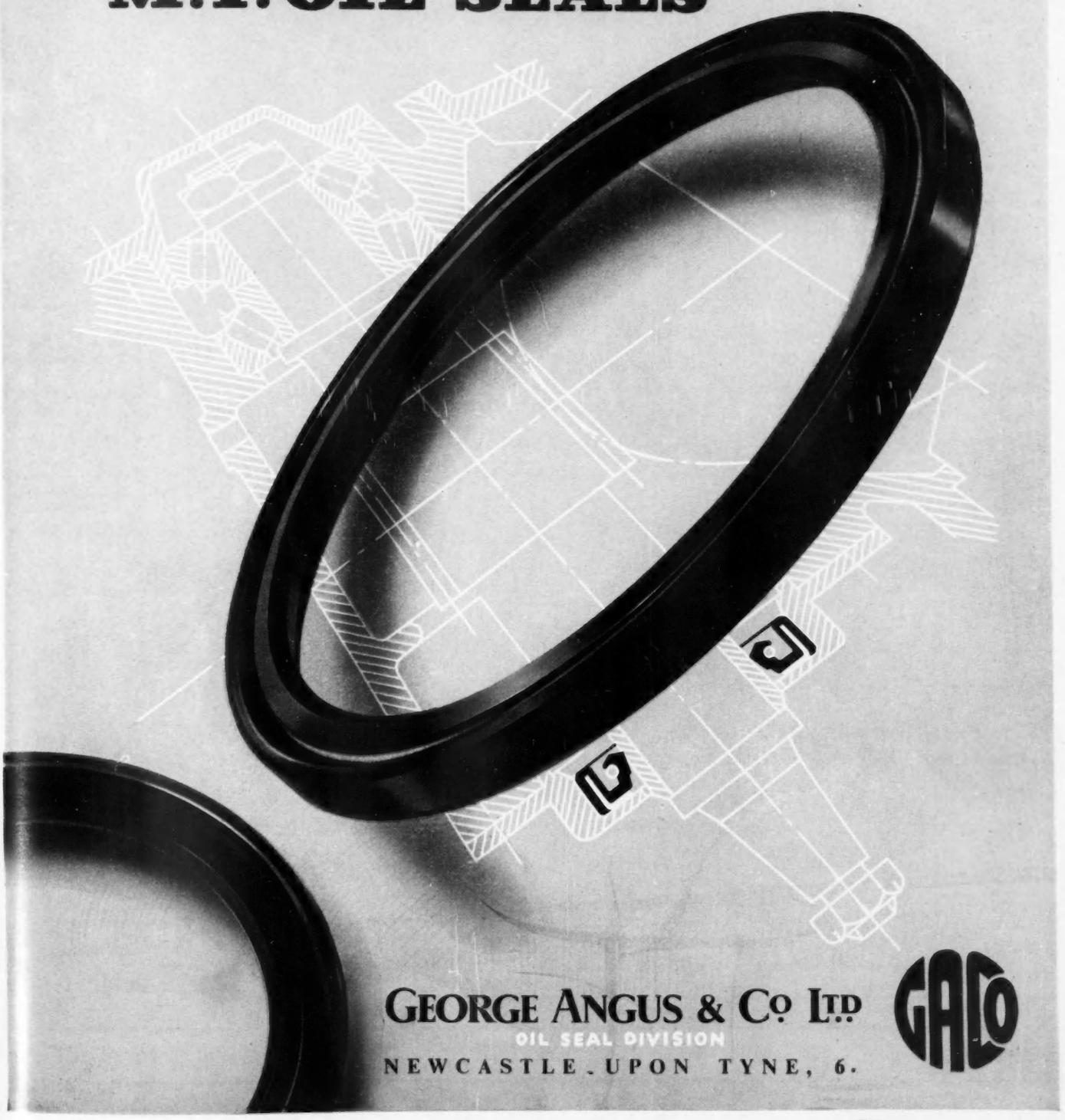

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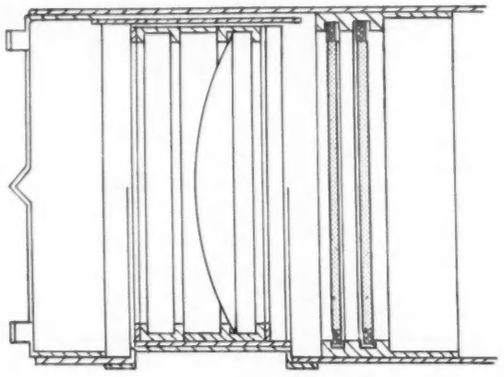

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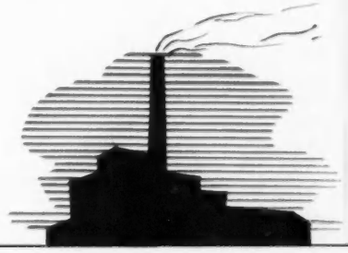

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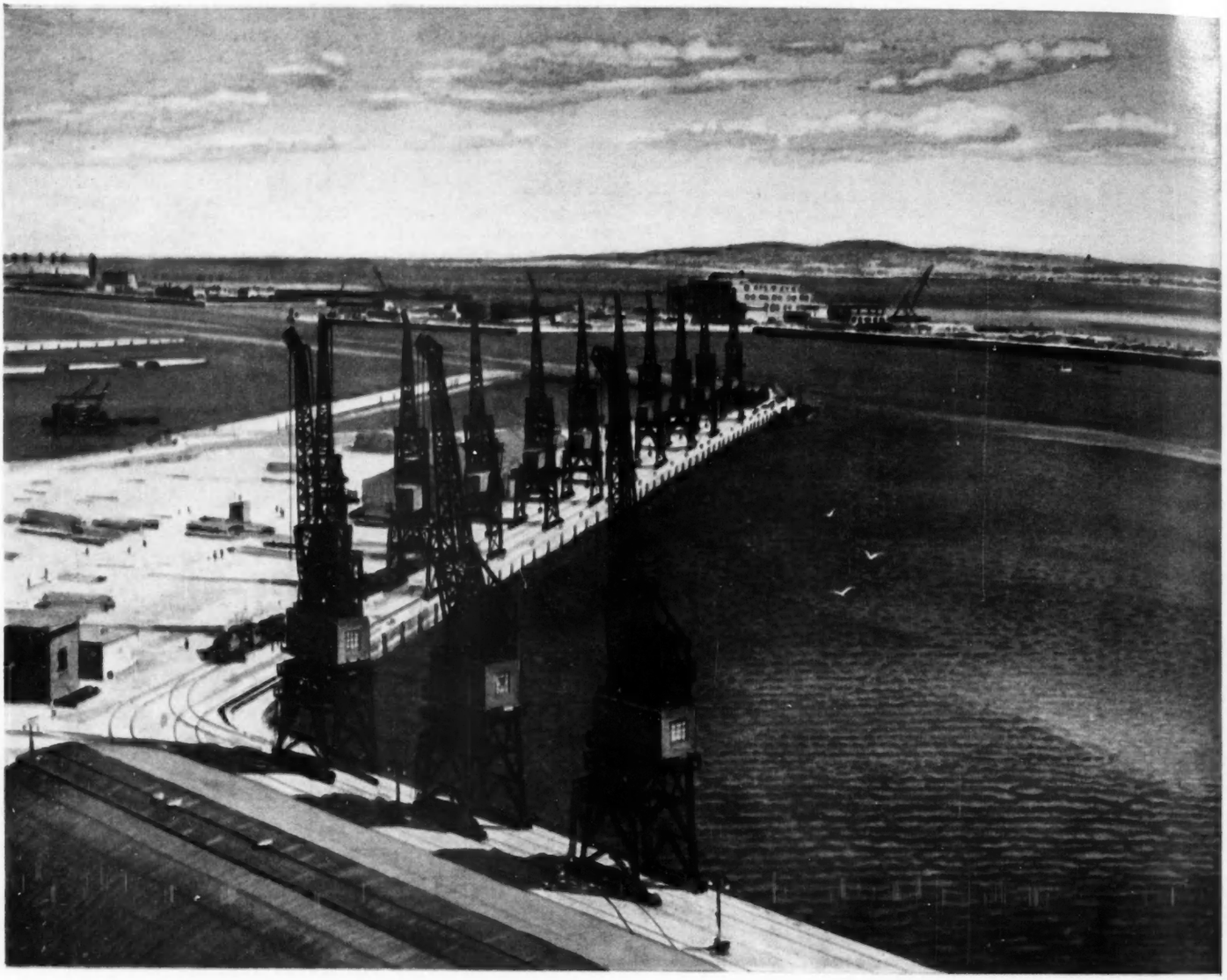

Dockside Cranes

Illustrated are some of the twenty-six Arrol cranes supplied to Dublin Port and Docks Board. A repeat order for seven similar cranes has recently been delivered and installed.

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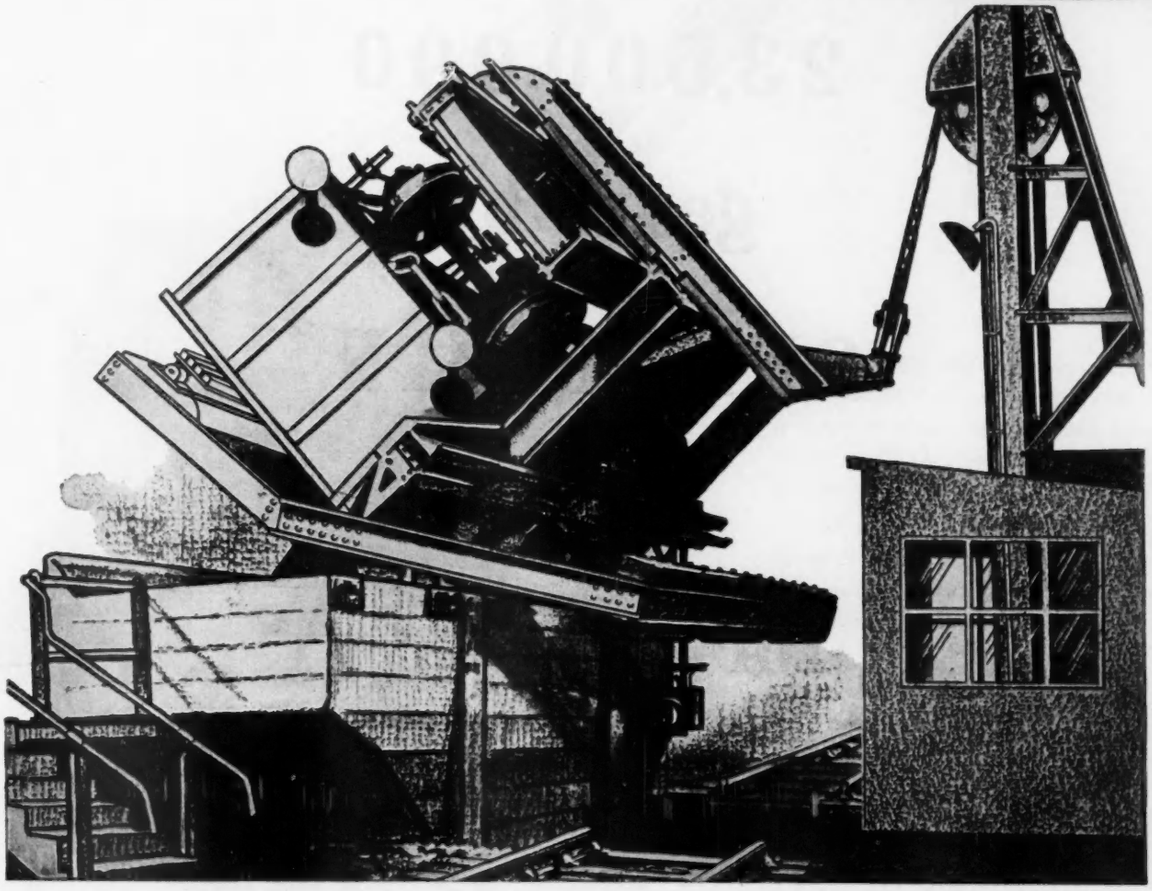
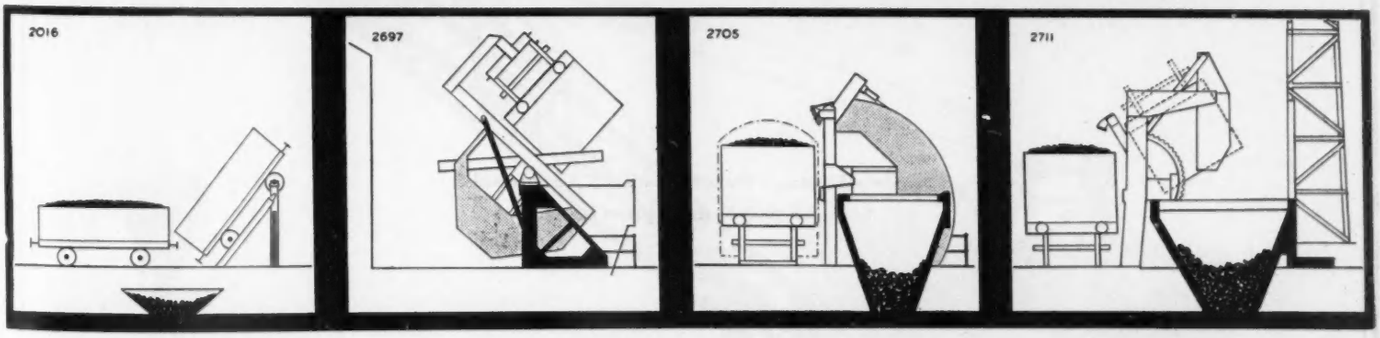
Wagon Tipplers by HENRY LEES & COMPANY LIMITED





In our range of wagon tipplers we continue to offer an unrivalled choice of machines to suit the varying needs of industry. Many years of experience in producing wagon Tipplers lie behind such new designs as are outlined in figures 2697, 2705 and 2711 above. We should welcome the opportunity to submit up-to-date particulars of suitable machines to meet customers' particular site conditions. All machines comply with the Railway Clearing House requirements.

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2697 Rope ram type side discharge tippler.
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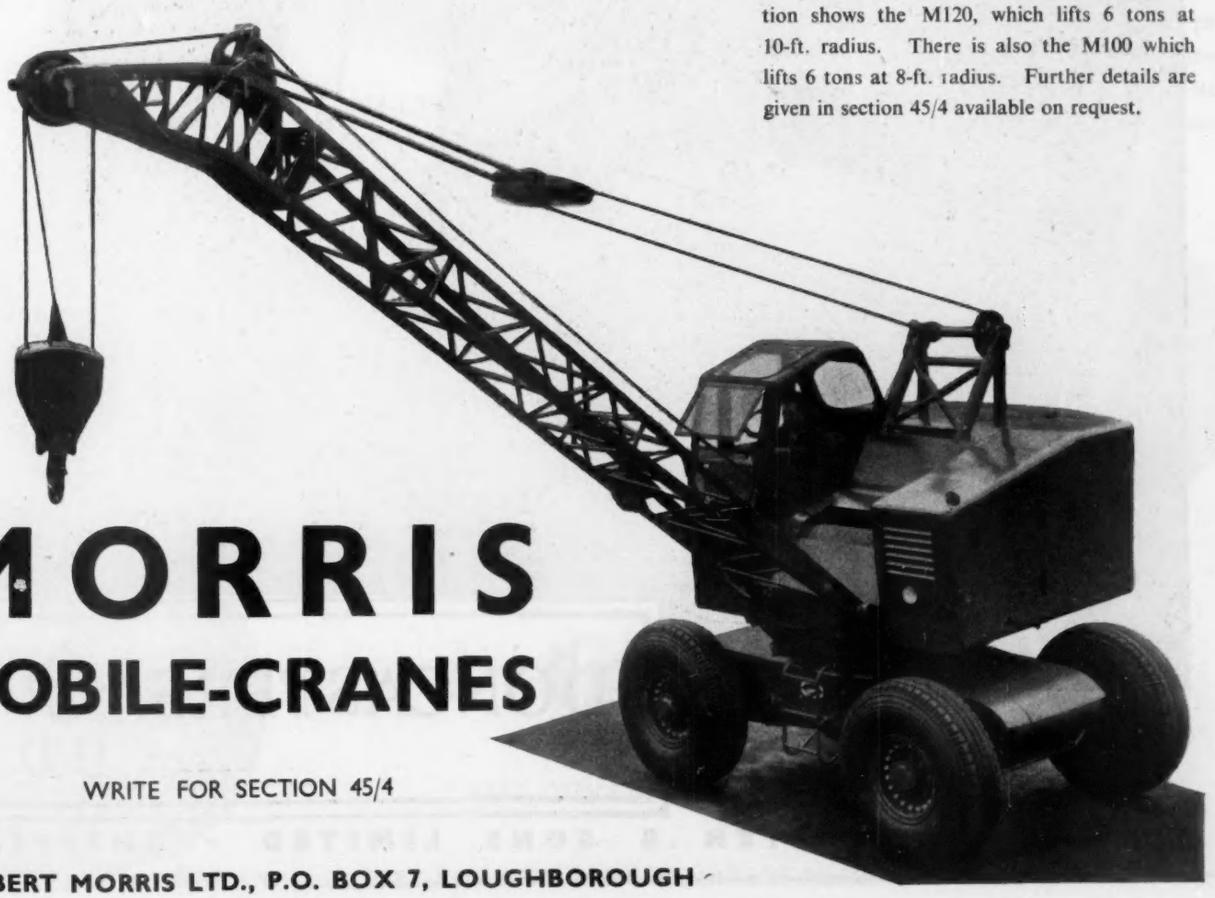
The upper illustration shows the M60 which lifts 3 tons at 10-ft. radius. The lower illustration shows the M120, which lifts 6 tons at 10-ft. radius. There is also the M100 which lifts 6 tons at 8-ft. radius. Further details are given in section 45/4 available on request.



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WRITE FOR SECTION 45/4

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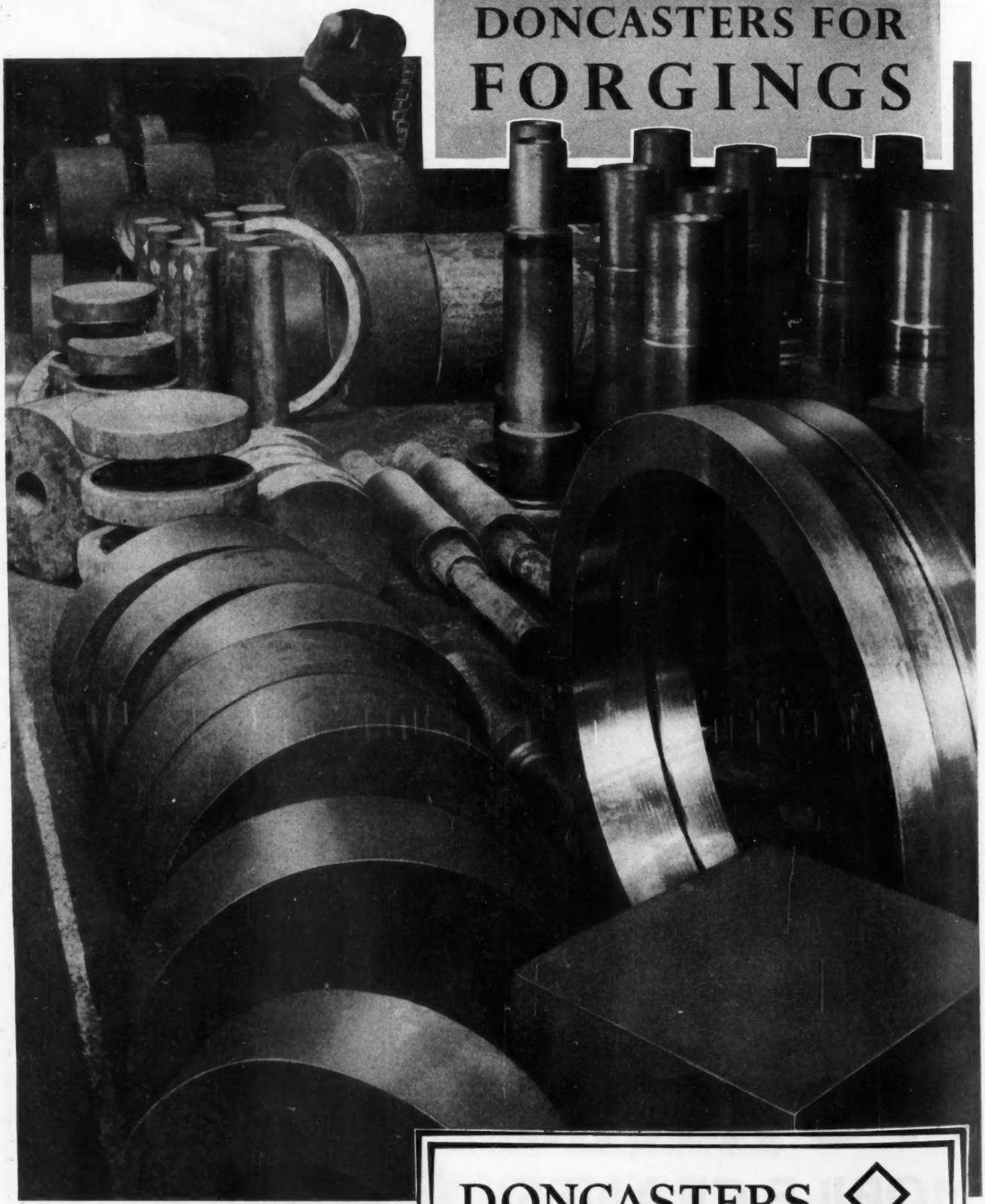

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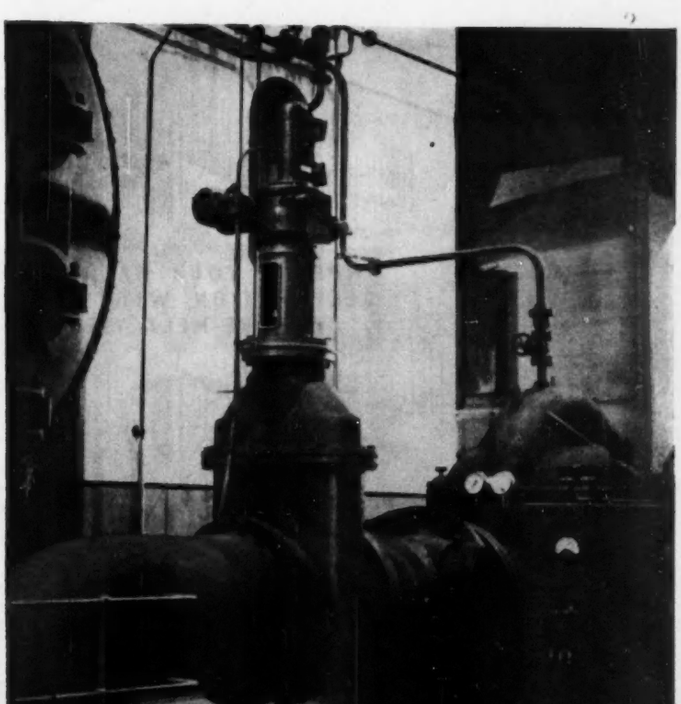

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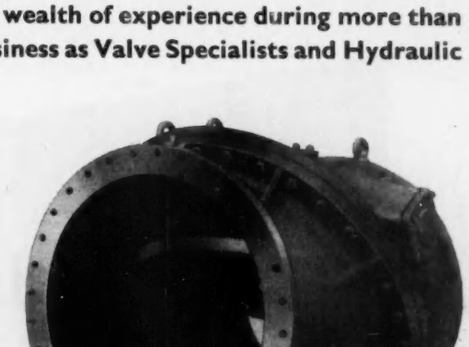

The site photograph shows a 24in. dia. inside non-rising screw electrically operated Sluice Valve and a similar sized Tilting Disc type Reflux Valve. The other illustrations show a 36in. dia. outside rising screw electrically driven Sluice Valve and a 48in. dia. Tilting Disc Reflux Valve.

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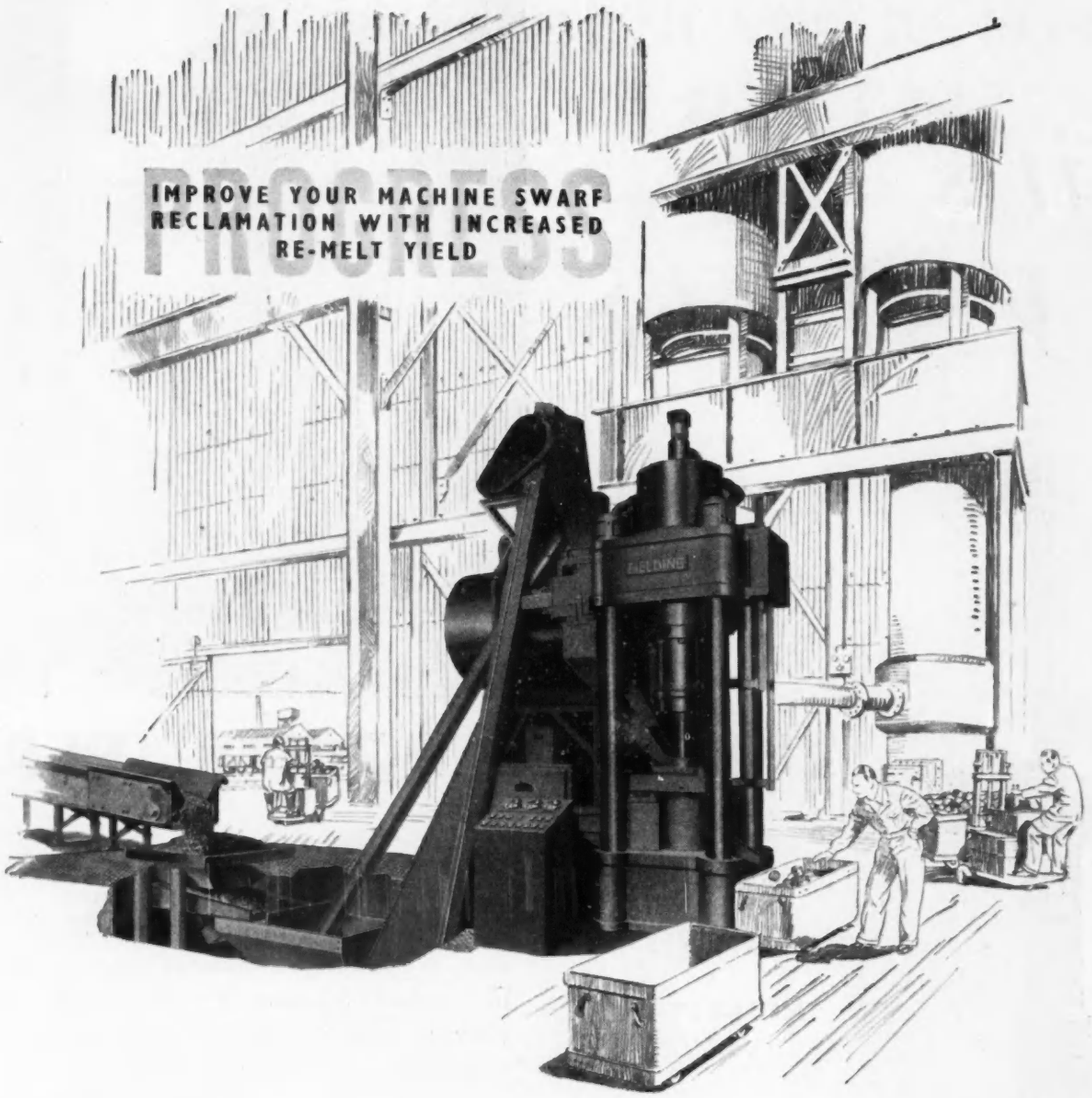

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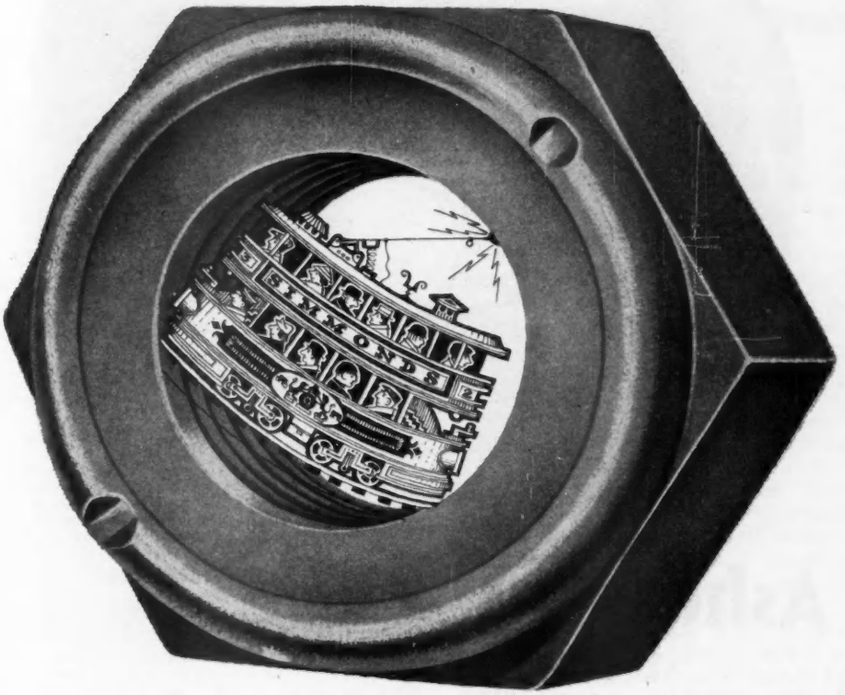

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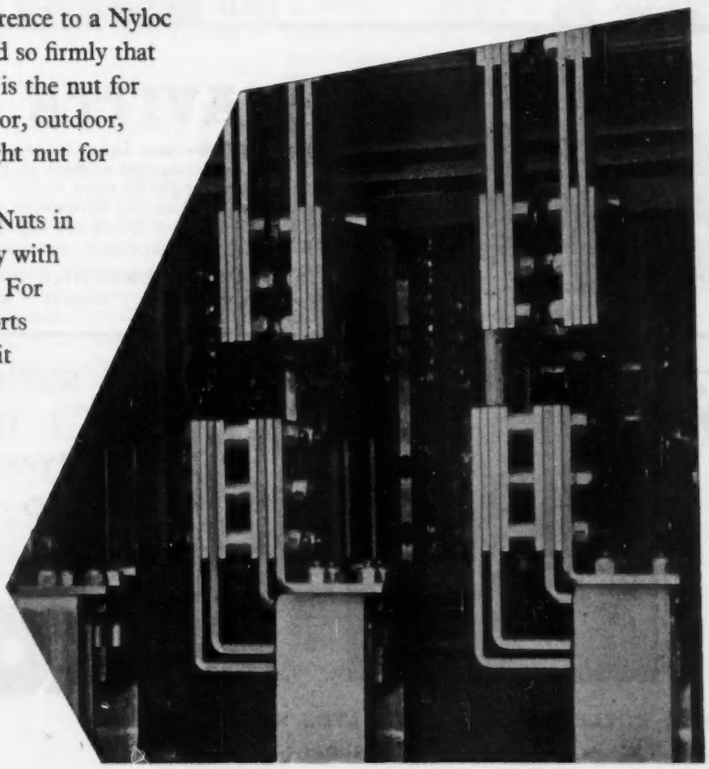

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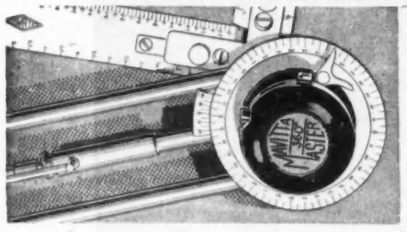

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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4712

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ACCIDENTS

In 1954, the number of industrial accidents reached 161,958, of which 708 were fatal and 26,221 were caused by power-driven machinery. Accidents on the roads, in which power-driven equipment plays a major part, every year kill 5,000 people and injure about a quarter of a million. It is, therefore, surprising that more thought has not been given to the relationship between machines and the men who operate them. Factory legislation has mainly been concerned to guard the machine so that human limbs are completely excluded or to provide means of ensuring that the machine cannot be fed or adjusted while it is in motion. These are well-nigh impossible ideals in the industrial situation, and it is an illuminating commentary on our attitude to accidents that no one has ever suggested applying these safeguards to the motorist.

An alternative approach to the problem has been the attempt to discover criteria of accident proneness and to select workers for machine operating on this basis. In a recent lecture entitled " Men, Machines and Accidents," and delivered at a meeting of the Association of Mining, Electrical and Mechanical Engineers Mr. J. W. Whitfield has expressed the opinion that there is little chance of devising a universal selection process to exclude the accident-prone except in occupations demanding great skill and responsibility for the safety of others; and, even if it could, the accident-prone would still exist and be entitled to earn a living.

An accident may be defined as either a failure to perceive a hazardous situation, or a failure to respond adequately to the situation perceived. Recent work by the industrial psychologists has examined these failures from the point of view of the relationship of machines to the men who use them and of the environmental and social conditions in which machine operating is carried out, and some extremely significant ideas are in the course of development. The avoidance of accidents, like any form of skilful manipulation, involves a " feed-back " process which comprises anticipating what the machine is going to do, deciding if action is going to be needed to correct it and, if it is, making the necessary limb movements to bring about the desired change, and checking back to ascertain that the action taken was correct. In skilled work all these actions take place continuously and instinctively, but whether they are more or less effectively carried out depends on the ease with which the operator is able to recognise and interpret " signals " from the machine, the arrangement of the controls which determines the speed with which he can effect changes, and the speed and accuracy of the response of the machine itself. With power-aided controls or where velocity or acceleration have to be adjusted, the combined behaviour of the machine and the operator can be highly unstable, as anyone who has driven a car on an icy road would agree.

On the whole, equipment will not be used which is inherently unstable, although it is a problem to which designers need to pay increasing attention as power and complexity increase. Insufficient attention, however, is being paid to the other half of the feed-back process; the supply of information in adequate time for control to be affected by the operator. Recent work on signalling devices on motor cars has demonstrated the importance of this aspect of accident prevention, and there is growing attention to the design of instrument dials on machines and in process-control stations, following the work done on aircraft instrument panels during the war. The car driver or the machine operator is not working in a vacuum and his speed of response depends on his ability to pick the relevant signals out of a mass of irrelevant noise and sensation, so that the physical background against which work of this nature takes place assumes increasing importance. In driving a car information is received from the road ahead and the vehicles and pedestrians on it, from lamp-posts, telegraph poles and trees and, at night, from every sort of illumination. Much more work needs to be done on the design and placing of traffic signs and road markings to assist the driver to pick out these essential items of information from the surrounding mass of impressions. Similar work needs to be done in industrial situations where the amount of information reaching the operator increases with the speed and complexity of the process.

Speed of response to information received depends on activities of the limbs and, although much is known about the desirable qualities of controls for limb movement, it is often not put into practice, as those who drive certain makes of car can testify. These are matters involving direct anatomical considerations, the positioning of controls, and the problem of optimum leverage, to which power-aided controls have added further complications by removing the " feel " of the control—an essential part of the " checking back " process of the combined human and machine feed-back mechanism.

The individual's capacity to respond quickly and accurately to sudden changes depends not only on his inherent or developed capacity, but also on his physical and psychological state at the time. Recent

research into work in hot and damp conditions has shown that in these conditions the angle subtended at the eye within which signals are perceived declines seriously. Ability to receive signals and to make accurate corrections in difficult tasks is also affected by fatigue. Personal anxieties, working or administrative frustration and irritation, spasmodic and unpredictable interruptions of work may all contribute to the errors in judgment and action which lead to accidents, and it is in the investigation of changes in human capacity due to these and similar causes that there may well lie the most fruitful field of research. Meanwhile there is increasing scope for collaboration between engineers and industrial psychologists in the improvement of the design of machines from the point of view both of the human frame and the human senses.

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Plain Words

The Government have evolved a brand new policy in the wake of the Tonbridge by-election result. Prices are to be held. The Central Electricity Authority and the Coal Board have committed themselves to a standstill in prices for one year. To quote the *Fianancial Times*: " few people will ever believe . . . that these two decisions were not a concerted part of a Government plan." This is not to say that economic stability is not the most basic of the country's needs. What is questionable is the manner in which stability is being sought.

The logical, in fact the inevitable next step, is to freeze the major element in costs—wages. In this, nation-wide agreement rather than pressure on a few boards will be needed. For a Government to be a party to the rejection of wage claims is, as Mr. Harold Wilson pointed out last week in the House, " likely to lead to widespread industrial strife." Yet the Treasury's own published views are that no improvement is likely to go far enough or fast enough " if there is any further rise in money incomes." If the contribution of the fuel and power industries to price stability is not to be lost in general inflation, therefore, or become a burden on the taxpayer, the private sector of industry—or at any rate the leaders within it—must give an undertaking similar to that given by the public boards. Even more important, the trade unions must be asked to peg wages. Their attitude will in fact largely determine the results of price restraint.

The question of wage restraint is far from simple, for any of the organisations involved. At any one time there are sections of trade unionists who lag behind others, generally on account of the timing of their claims. Then there are differentials. All anomalies—and most differences can be construed as such unless there is goodwill—will have to be resolved before the T.U.C. can do as much as give a lead. If they will not co-operate, or if they cannot carry their followers with them, then the Government are left in the perilous position of having to impose their will. In this way they are unlikely to succeed unless they are also willing to freeze profits and to increase company taxation—not to-day a vote-catching formula.

Mr. Eden has declared roundly that in a free society the fixing of prices and wages by legislation was not the right solution. In the present mood precious few arguments are likely to result from discussions with organisations outside the Government's control. What is needed is leadership of a type that will convince the whole community that wage and price restraint is the life-need of the nation. This is the test that the Government have to face.

The Convair rain-erosion test sled at the start of a run. The sled is started by a pusher sled, with five rocket bottles, over the first 950 ft. of track; at this point the 12 bottles on the test sled itself are automatically fired.

MACH 2 ROCKET SLED

RAIN EROSION TESTS ON MISSILES

A new rocket sled constructed by Convair Division of General Dynamics Corporation, San Diego, California, has set a " world speed record for recoverable sleds " at 1,560 m.p.h. on the 10,000 ft. high-speed track at the United States Air Research and Development Command's flight test centre at Edwards Air Force Base, California. Speeds in excess of Mach 2 are to be reached on a regular schedule in the next few weeks during rain erosion tests.

The sled is designed to race through a simulated rain storm at supersonic speeds, carrying an exposed part of an aircraft or missile. Recovery of the sled at the end of its run with no damage from deceleration is essential in order to evaluate the effect of rain erosion on the part being tested. To accomplish this, Convair designed the sled to weigh only 800 lb., whereas other test vehicles weigh up to 5 tons. Parts of the sled's tubular structure are used as a water brake, a recess for telemetering equipment, a platform for specimens, and as a secure mounting for the rocket motors.

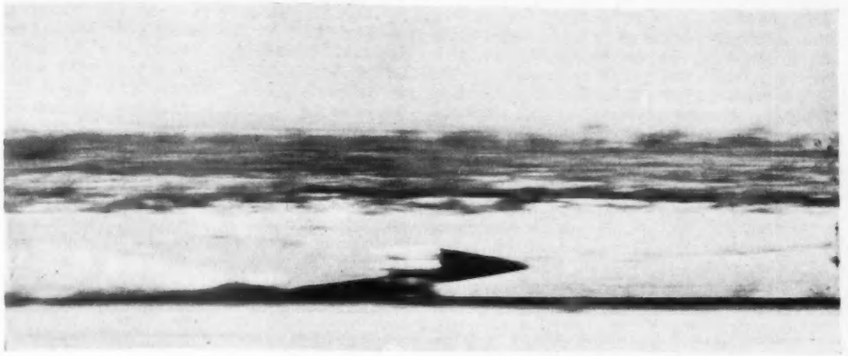
This light weight, which gives the sled its rapid acceleration and high speed, also permits rapid decleration without running the vehicle off the end of the track and destroying the sled and its test equipment. Low and sleek, with rockets mounted over the front pair of runners, the Convair sled presents a minimum of frontal area.

For rain erosion research, the technique previously employed by Convair was to fire material samples with a 20 mm. gun through simulated rainfall. This technique, however, limited testing to very small specimens. With the rocket sled—a relatively inexpensive testing device—complete sections can be subjected to rainfall, without risking a full-sized aircraft in flight.

To reach a speed of Mach 2, the Convair sled is equipped with 12 rocket bottles, seven on the sled and five on a pusher sled. The pusher sled accelerates the test unit to a speed of more

Artificial rainfall is provided along 1,200 ft. of track by spray stands supplied from a 100 ft. water tower.

than 620 m.p.h. in the first 950 ft. of the track. The rockets on the sled are fired automatically at this point and it accelerates away from the pusher sled with a force of 25 *g*. The sled firing mechanism is a bronze screen stretched between the track which, when cut by two knives



1,560 m.p.h. on the track.

mounted on the sled, passes a 600 volt current of electricity through igniters on the bottles.

Four steel slippers are used keep the sled on the track during its 9½ second run The slippers are lined with stainless steel inserts which ride on the top and underside of the rail flange. During the run, these inserts reach temperatures of 1,500 deg. F. The flow of metal particles from the inserts reduces friction so effectively that engineers no longer take it into account in calculations of sled performance. A slipper insert lasts about four runs.

Telemetering equipment is built into 37 in. of the sled's framework. The frame is made up primarily of three curved and welded 5½ in. diameter steel tubes with a wall thickness of about $\frac{3}{16}$ in.

Bendix accelerometers measure the vertical, lateral, and longitudinal accelerations throughout the run. A miniature transmitting set, part of the telemetering equipment, beams this information to a recording centre. The speed of the sled is measured by a magnet on the frame passing over coils located at intervals along the track. Recording oscillographs in the telemetering room at the track measure the speed of the sled by registering time intervals, measured to an accuracy within 0·0001 second, between 50 ft. lengths of track.

Metered rainfall is simulated by sprinkler nozzles on 6 ft. stands along 1,200 ft. of track, supplied from a 100 ft. water tower.

The standard rail sled track is anchored in concrete by adjustable straps that permit alignment within 0·05 inches.

Stopping the sled without destroying it—which is more of a problem than propelling it at speeds faster than sound—is accomplished by momentum transfer, through a water brake effective up to 35 *g*. A water scoop is built below the sled frame. The frame is curved back over the twin rear slippers, channelling water up out of a 2,000 ft. trough, turning it through 160 deg., then discharging it out both sides at the rear. The track slopes below the trough level, permitting the scoop to enter the water gradually. Water jetting out from the frame of earlier sleds struck 6 in. steel I-beam camera supports with such force that the beams were bent and in some cases torn from the steel bolts holding them to concrete foundations. New water-exhausting techniques correct this difficulty. The water is accelerated to approximately 1,300 m.p.h., developing 20,000 lb. braking force.

Part of the recording equipment operated by rocket track personnel consists of Eastman motion-picture cameras which can take 7,000 frames of black-and-white film per second. Colour film is run at a slightly lower speed.

Development of the Convair supersonic sled was the result of joint technical efforts of the Convair thermodynamics laboratory and the Experimental Track branch of the Air Force flight test centre. The research programme is under direction of the Materials Laboratory of the Wright Air Development Centre.

THE OIL INDUSTRY IN 1965

The world is now engaged on one of the greatest and most sustained periods of economic expansion and human activity ever recorded. Yet without an adequate supply of natural resources this activity will be stifled. Above all, increasing national and world prosperity will depend upon an adequate supply of energy. Nuclear power will play an increasingly important part, but the big growth in energy requirements over the next 10 years will have to be met by petroleum. A recent study* puts into figures the implications of this demand to the world petroleum industry.

An analysis of the demand for oil over the past quarter of a century suggests the operation of certain laws of growth. Oil demand appears to follow compound interest curves which resist all but the most formidable distorting influences. Past trends indicate that the consumption of oil within the United States has increased at an annual rate of 5·8 per cent., while for the remainder of the Free World the comparable figure is 11 per cent.

If these trends are projected forward it can be gathered that there will be an aggregate demand in the Free World by 1965, of about 1,524 million tons per annum, compared with 691 million tons in 1955. Trends are shown in the graph which appears at the foot of this column.

TABLE I.—*Plausible Free World Petroleum Demand*

Area	Millions of tons per annum			Change 1965 from 1955
	1955	1960	1965	
United States ..	406	498	620	Plus 52·7 per cent.
Other countries ..	285	407	581	Plus 103·4 per cent.
Total free world	691	905	1,201	Plus 73·7 per cent.

TABLE II.—*Energy Demand and Supply* (10^{14} *B.Th.U.*) *(Free World Excluding U.S.A.)*

	1954	1965
Total energy demand	319·0	564·2 max. 459·1 min.
Supplied by:		
Coal and lignite	201·2	213·7
Natural gas	5·1	20·8
Hydro-electricity	9·7	18·0
Balancing demand for petroleum demand	102·9	311·7 max. 206·6 min.
Petroleum demand, million tons per annum	243·5	737·5 max. 488·8 min.

* *Future Growth and Financial Requirements of the World Petroleum Industry*. Joseph E. Pogue and Kenneth E. Hill, Petroleum Department, The Chase Manhattan Bank, New York.

EFFECT OF TECHNICAL INNOVATION

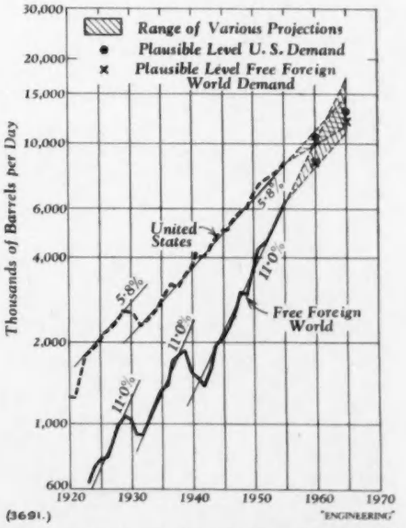
However a simple extrapolation of past trends takes no account of economic disturbances, or technological changes, which may tend to "downfault" the curve, or substantially modify the growth factor. The Diesel-conversion of the United States railways completely altered the growth rate of fuel-oil consumption in the U.S.A., and similar results are likely to obtain in this country. Other estimates have, however, been made which attempt to take account of these influences, and by taking the median of 20 different estimates the authors of the booklet arrive at a "Plausible Free World Petroleum Demand" which is given in Table I.

These estimates are arrived at principally by projecting existing trends. Another method of approach is to estimate total energy requirements for the Free World in relation to the growth of population and industrial activity, and then to apportion this demand among available energy sources. The rate at which demand for effectively-used energy per head in the United States is likely to increase over the next 20 years has been estimated at 3 per cent. per annum. In the rest of the Free World this rate is likely to be substantially higher to allow for more rapid growth in the less developed areas, and in terms of 10^{14} B.Th.U. the 1954 consumption of 322 may rise to at least 459 and perhaps to 564 by 1965. While hydro-electricity, natural gas and coal may all increase their contribution over the period, undoubtedly the gap must mainly be filled by petroleum products. The energy demand and supply equation will thus be made up as in Table II.

This estimate admittedly gives a wide range, and the Chase Manhattan Bank's "plausible" estimate lies in the lower half of the range. A simple projection of the existing growth trend, however, would place the 1965 demand beyond the maximum in the above table. Under the circumstances it would perhaps not be unfair to question whether the Bank's estimate errs rather on the side of caution.

BRINGING THE OIL TO MARKET

While there are ample reserves to meet any likely demand within the next 10 years, these reserves are unevenly distributed relative to the sources of demand; 17 per cent. of reserves are located in the United States and 83 per cent. elsewhere, four-fifths being in the Middle East. The growth of oil supply is principally a function



Past growth trends for petroleum demand with projections to 1965.

of three factors: the size of the proved reserves, the rate at which new reserves are discovered, and the rate of drilling. Where reserves are large, as in the Middle East, and the U.S. offshore areas, output can readily be increased by drilling more wells. But where the ratio of reserves is moderate, say reserves 10 to 15 times annual production, output must be more closely related to the rate of discovery of new oil. In the United States the cost per barrel of finding and developing new sources of supply in the last 10 years has more than doubled. In the Middle East the limiting factor, however, is the provision of transport and other facilities necessary to bring the oil to the markets of the world. The demands which will be made upon this area in the future however, will be so great that the rate of discovery of new sources of supply will be an increasingly important factor.

A summary of the authors' calculations on the supply of Free World petroleum is given in Table III. Setting this against the estimates of demand, the extent to which the United States will come to depend on foreign supplies is brought out. The study suggests that the U.S.A. will need to import a total of around 155 million tons per annum by 1965, if demands are to be fully met.

TABLE III.—*Supply of Petroleum in the Free World*

Area	Millions of tons per annum			Change 1965 from 1955
	1955	1960	1965	
United States	363	429	478	Plus 31·7 per cent.
Rest of free world	331	474	711	Plus 114·9 per cent.
	694	903	1,189	Plus 71·4 per cent.

The expansion of the petroleum industry on such a scale as has been indicated calls for a prodigious programme of capital formation. Over the next decade the industry will need to expend about 115 billion (10^9) dols. of which 73.5 billion dols. will be required by the U.S. and 41.5 billion dols. by the rest of the Free World. About 40 per cent. of this latter figure will be spent on exploration and production and about 21 per cent. on refining. In the U.S.A. on the other hand, exploration and production takes about 70 per cent. When it is realised that the " dry hole " ratio in the U.S.A. is now nearing 40 per cent. this disparity is not surprising.

The authors attempt to break down the sources of this finance as between depreciation charges, fresh capital and ploughed-back profits. For the United States it is estimated that the bulk of requirements will be met by depreciation charges and only 10½ million dols. will be obtained from the capital market.

THE YEAR 2000

For the rest of the Free World the authors confess that they are unable to estimate the sources of the finance and content themselves with a 41½ million dols. estimate of investment required over the 10 year period. It is extremely unlikely, however, that any substantial proportion of this can be met from sources outside the industry. The Royal Dutch/Shell group alone will require about £1,000 million over the next three years, and yet an issue of £50 million would be difficult for the market to swallow at the present time. Consequently it can be assumed that perhaps not more than 5 to 10 per cent. of new capital will be found outside the industry with the balance being split between depreciation charges and ploughed-back profits, the former preponderating.

What of the prospect beyond 1965? The authors have, perhaps wisely, left this highly speculative long-term forecasting aside, wishing to preserve their reputations. Mr. J. W. Platt, a less timorous soul, and a managing director of the Royal Dutch/Shell group, in a paper recently read to the Institute of Petroleum, estimated that oil demand by 1975 would probably reach 1,600 million tons per annum at a minimum. Beyond then a rapid increase in the production of nuclear energy could be looked for, but even assuming its total contribution to energy supplies to be one third by the year 2,000 a fourfold increase in oil production would still be required.

Letters to the Editor

ROAD SAFETY

SIR, I have recently read *The Skilful Driver*, by Dr. J. S. Blair. This book was mentioned in a Weekly Survey note in ENGINEERING (April 27, page 262, 1956).

As one who has devoted no small amount of time and energy to the furtherance of road safety, particularly toward an improved standard of driving, I would point out that this book is a dreadful testimony to the fact that even drivers of long experience are guilty of many dangerous practices, and contrary to their own self-satisfied views, are still completely ignorant of the finer points of really expert driving.

It is a great pity that this book was ever published. Far too many people are so ready to accept without question anything seen in print, and aimed as it is at the inexperienced motorist, the book constitutes a grave menace to this majority section of road users.

Dr. Blair is entitled to his own opinions on all the age-old arguments relating to driving technique, but it is to my mind little short of horrific to see a text book on so-called advanced driving in which the author advocates holding the steering wheel by the spokes (" the thumb is handy for the horn "); resting the right elbow on the window ledge, and considers that it is correct (and safe) to drive 12 in. from the kerb.

It is also astounding to read that one's speed downhill, even on ice, is checked by braking; this being only one of several statements (and omissions) in the book which suggest that the author's car is not fitted with a gearbox.

Dr. Blair also tells us that he is in the habit of sounding a long reproachful blast on the horn at those drivers he considers to be offending. Apparently he does not know that this is not one of the legal uses of the horn, but even greater illegalities follow in that we are told of the joys of coasting, out of gear, with engine switched off (" a pleasant sensation rather like gliding ").

Whilst on the legal aspect, there is a most blatant example of the author's knowledge (or lack of it) in that he confesses that he does not know whether a motorist commits an offence by driving along the footpath.

These are but a few of the many pieces of fatuous nonsense contained in this deplorable book, but I think the last straw comes when we are told of the wonderful benefits of fitting an altimeter on our car " for touring in hilly country " !

On his own testimony, Dr. Blair's standard of driving is of the type that police forces throughout the country together with road safety workers like myself, are trying to stamp out by the education of such drivers, who would ordinarily fail the Ministry of Transport learner driver's test.

The book is a positive menace to the motoring fraternity, and should it become widely read, I am afraid we can expect a sudden steep rise in the accident rate.

Yours truly,

LESLIE W. POWER.

Penn Fields,
Wolverhampton.
June 21, 1956.

* * *

Obituary

PROFESSOR J. J. GUEST

It is with regret that we note the death of Professor J. J. Guest, which occurred in his 90th year, at Virginia Water, Surrey, on June 11. He will be chiefly remembered for his work on the strength of materials and on grinding phenomena.

James John Guest was the son of the late Rev. J. M. Guest, and was born at Handsworth, Birmingham, on July 24, 1866. He was educated at Marlborough College and at Trinity College, Cambridge, and became a 5th Wrangler obtaining the B.A. degree in 1888. He also became a member of the Institution of Mechanical Engineers. After practical training in several private workshops and in the drawing office of Tangyes Limited, Birmingham, Guest left this country in 1894 to take up the post of assistant professor of engineering at McGill University, Montreal. Two years later he was appointed head of the engineering department at the Polytechnic at Worcester, Massachusetts, U.S.A. In 1900, Guest returned home and for the subsequent 15 years acquired practical engineering experience, in Birmingham and Coventry, as partner in the firm of James J. Guest and Company. In 1916, he was placed in charge of inspection in the Staffordshire and Shropshire Munitions Area under the Ministry of Munitions, but, in the following year gave this up to re-enter the teaching profession having been appointed Reader in Graphics at University College, London. His final appointment was that of Professor of Mechanical and Electrical Engineering at the Artillery College, Woolwich, which subsequently became the Military College of Science. After his retirement he undertook consulting work.

Professor Guest carried out much research work on the strength of materials and contributed a number of articles on this subject to our columns. Among the last of these was a long thesis on combined stress which we published in our volume 155, of 1943. Since then he had contributed several letters on stresses and strains. He was the originator of Guest's Law on Combined Stresses and had also conducted investigations on such matters as grinding and vibration problems.

* * *

MR. E. B. WEDMORE, C.B.E.

A Leader in Electrical Research

Mr. E. B. Wedmore, whose death we regret to record occurred in London on June 16 at the age of 80, was well-known to engineers for his work as first Director of the British Electrical and Allied Industries Research Association. In this position, which he held for 24 years, his technical knowledge and administrative ability led to results of the first importance in such varied fields as the design of circuit-breakers and turbine nozzles, the properties of steam, metal creep, surge phenomena, radio interference and dielectrics.

Edmund Basil Wedmore was born in Bristol on January 24, 1876, and was educated at University College in that city. He subsequently served in the Corporation Electricity Department and from 1896 to 1899 was lecturer at Finsbury Technical College under Silvanus Thompson. He then joined the British Thomson-Houston Company with whom he worked for 18 years, finally as chief switchgear designer.

In 1919 he was appointed technical officer to the Electrical Research Committee and two years later became Director and Secretary to its successor the British Electrical and Allied Industries Research Association. During his tenure of this post the staff increased from two to 175 and work was carried on by over 100 committees and sub-committees in the activities of which he took detailed interest.

Wedmore was appointed a Commander of the Order of the British Empire in 1938. He became an Associate of the Institution of Electrical Engineers in 1897, an Associate Member in 1902 and a Member in 1912. He had served on the Council of that body and had contributed papers to the *Proceedings* for which he had received Institution, John Hopkinson, Kelvin and Student's Premiums. He was also a Fellow of the Institute of Physics. He was the author of *Switchgear for Electric Power Control.*

Weekly Survey

Cover Picture: *A further stage in the manufacture of a seamless alloy-steel cylinder intended for the storage and transport of oxygen and other gases under high pressure is shown in our cover picture this week. The rounded dome-like base of the cylinder is seen being finish-machined.*

★ ★ ★

The Long and Short of It

So far as the immediate future is concerned, the Government seems to be reasonably happy about the trend of economic events. Changes are small but they are in the right direction. Exports continue to rise and so does the demand in the home market for plant and machinery. The volume of retail sales in the first four months and there has been, within the group, large falls of 1956 was slightly lower than in the year before in the sales of consumer goods. This interpretation does not add up to complacency. A further large increase in exports is considered to be necessary and there is obviously concern lest wages and salaries should go on rising and so stimulate inflation.

In regard to the more-distant future, however, signs are not lacking of wishful thinking. The long-awaited official pronouncement on the £100 million cut in Government expenditure, which was first heard at Budget time, may well have been made before this issue is in the reader's hands. It is known that the Government is undertaking the major revision of defence policy over the next year or so in the hope of achieving major economies. Some wild guesses have been made about the size of the cuts which would be possible. Only a drastic (and possibly foolhardy) stripping of our defences will achieve the savings of hundreds of millions of pounds a year which have been mentioned in some quarters. The argument for large cuts in defence expenditure has an insidious charm of its own for perplexed politicians and heavily taxed electors. Resources tied up on defence projects could, if released, be switched to exports and the home market, thus alleviating inflation at home and a tardy expansion of exports abroad. All this can be considered in terms of fighting an economic war in foreign markets against the Russians. It should be viewed with the utmost suspicion. It would be a sorry day if this country's only answer to guided missiles massed for destruction were some excellent prototypes awaiting quantity production and, say, a mass of tractors, in the rice fields of Burma.

★ ★ ★

Struggle for Car Exports

British car exports in May were slightly higher than in April, but 11 per cent. less than in May last year. The daily average was still lower than in April, yet the fact that they accounted for a higher proportion of output—53½ per cent. in May, compared with 49 per cent. in April—was encouraging. Production in May was nearly one quarter less than a year ago, but there is a widespread belief in the industry that the performance in June will be much better. Perhaps the most significant development is the substantial reduction in stocks over the past three months, when home sales and export deliveries have exceeded output by 30,000. Home sales in April—estimated at 41,000 cars—were only 6½ per cent. below the corresponding figure for 1955. Waiting lists for the popular models have increased and delivery delays of 3 to 4 weeks are being quoted by dealers, who are not yet able to quote any delivery date for the new Fords and Hillmans.

The Society of Motor Manufacturers and Traders issued an optimistic statement last week about exports, which "show the trend of development of our manufacturers' sales drive in some of the hotly contested European markets" and instanced increased deliveries to Sweden and Germany. The next three months will show whether or not the German industry's gains at our expense can be halted. German car exports are currently running at an annual rate of 500,000, or about 20 per cent. higher than last year. The most successful exporter, Volkswagen, have recently decided to limit exports to half total output (at present 55 per cent.) in order not to leave the home market to their competitors. With delivery dates extending up to 7 months, they have been losing ground to Opel and Mercedes who are able to quote only a few weeks.

The future prospects of the industry are still the subject of controversy. Herr Koennecke, chairman of Daimler-Benz, warns of the dangers of over-expansion and says that his company are concentrating on the introduction of automation to reduce unit costs. Perhaps the most surprising aspect of car sales in Europe, including this country, is the indifference of buyers to hire purchase restrictions, sales taxes and the credit squeeze. Provided British cars are well sold and well serviced, there would appear to be a real prospect of a substantial increase in export deliveries during the next few months.

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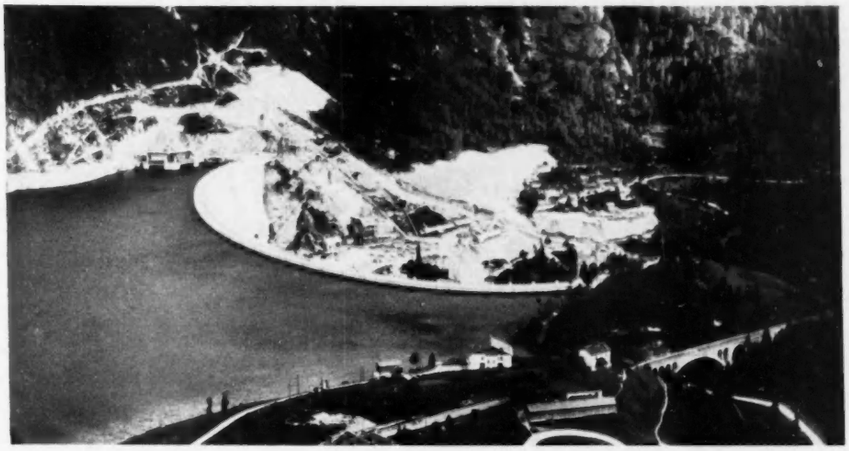
Take-Over Bid for Standard?

Persistent buying of the shares of the Standard Motor Company and rumours of a bid for control sent up the price of the 5*s.* ordinary stock from 6*s.* 1½*d.* to 9*s.* 1½*d.* in three months, 1*s.* 6*d.* of the increase taking place last week. The Chrysler Corporation and the Massey-Harris-Ferguson Company (who take up the capacity of the Banner Lane factory for the manufacture of the Ferguson tractor) were thought to be the buyers, but both have issued disclaimers. The Fiat Motor Company were also mentioned as a possible interested party, and have denied it. That their name should have been associated with Standard's may have been due to an offer of the control they are said to have received some time ago, which they turned down on the grounds that they did not wish to expand production in countries outside Italy.

The rumours are likely to persist. A growing number of people in the industry believe that the days of the smaller manufacturers are numbered since in their view they cannot compete with the giants (Ford, B.M.C. and Vauxhall). Recent performance tends to confirm this, except perhaps in the case of Rootes who have been remarkably successful with their new Hillman and Sunbeam models. Between the wars there was a gradual elimination of independent car manufacturers, most of whom were acquired by large manufacturing groups for their prestige value, or were successful in expanding into wider industrial fields. But in the main they were manufacturers of custom-built cars, such as Alvis, Aston Martin, Bentley, Lagonda, Rolls-Royce and others. The same considerations do not apply to Standard, or for that matter to Rootes or Rover. Their cars are made in substantial numbers and could hardly be labelled "custom-built." In their case therefore, a purchaser's interests are more likely to centre in the available factory space and labour than in the products. Hence the plausibility of rumours linking the names of Chrysler and Fiat with Standard's. It could equally be Citroen, or Volkswagen, or another large U.S. manufacturer. It could also be one of the British manufacturers.



Arch-gravity dam at Pieve di Cadore. (See "Experience for Sale.")

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Experience For Sale

Experience is a valuable commodity. But unless it can be put adequately to use it becomes a liability. During the last 50 years the Italian companies Sade (Società Adriatica di Elettricità), Fiat and Montecatini have played a major part in the exhaustive exploitation of Italian electrical resources, and have been concerned both with natural-gas and ordinary thermal stations and also complete hydro-electric projects. Sade, for example, have been pioneers in the development of the arch dam, which retains the water by its shape rather than by bulk, so effecting economies in materials. The arch-gravity dam at Pieve di Cadore is shown in an illustration on this page. Now that most of these resources have been tapped and Italian requirements largely met, the combined electrical engineering experience of the three companies is to be put at the disposal of less highly developed territories, and to further this aim Sade, Fiat and Montecatini have jointly formed the consulting organisation Electroconsult, 13 Via Cavallotti, Milan.

The services offered by Electroconsult are generally similar to those provided by other consulting firms and include surveys and studies for co-ordinating and expanding the activities of the power industry; preliminary plans and comparative cost estimates for alternative designs; contract plans, specifications and estimates of quantities and costs: organising bids and preparing contracts; supervision of construction, and starting up; and assistance in maintenance, modifications and extensions. Some of the fields in which work can be undertaken are: base and peak load power stations; run of river, storage and pumped storage plants; thermal installations operated by condensing or back-pressure steam turbines, by Diesel engines or by gas turbines; transmission lines and transformer substation; distribution systems; hydraulic works connected with river development and multi-purpose projects; storage and control reservoirs; waterways such as canals, aqueducts,

tunnels and pipelines; and drainage and irrigation systems.

These details, together with data on projects already completed by the three companies and a bibliography of technical publications by engineers whose services will be available to the new organisation, are given in fully illustrated and documented handbooks in English and other languages recently published by Electroconsult. These also provide information concerning the laboratories and research centres which the three companies own, or to which they have access.

Electronconsult is thus a solution to a problem which may become increasingly common in a world divided into highly developed and underdeveloped areas. As the west approaches technical saturation it will require new kinds of engineering knowledge, and the experience gained during the long period of industrial growth will be at a discount. If this is not to go to waste, new outlets must be found.

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New Sources of Nickel

The continued shortage of nickel has stimulated production from new sources and has already considerably altered the world pattern of production. In spite of a rise in Canadian output from 258 million lb. in 1949 to 349 million lb. in 1955, the Canadian share of total Free World production has declined over this period from 97 per cent. to 80 per cent. The principal sources of nickel outside Canada are Cuba and New Caledonia, and it has recently been reported that a new plant with a capacity of about 30 million lb. per annum is to be erected in Cuba, while, in addition, it has been proposed to expand the existing plant, which is owned by the U.S. Government, by about 20 million lb. per annum.

The U.S. Government plant in Cuba began operation under the management of the Nicaro Nickel Co., a subsidiary of the Freeport Sulphur Company, during the war but was shut down in 1947. It was reopened in 1952 under the management of the Nickel Processing Corporation in which the National Lead Company now has a majority interest. The processing of the Cuban laterite ore presented many technical difficulties, and the wartime operation of the plant was uneconomic. It has, however, been stated that profitable operation was achieved in 1954, and the fact that the Nicaro Nickel Company is now erecting its own plant to recover nickel from the nearby Moa Bay laterite ores would suggest that Cuban nickel production is becoming established on a competitive basis.

It is as yet too early to say how soon world production of nickel is likely to overtake demand, but some easing of the supply position is a matter of considerable importance to the engineering industry. According to the chairman of the International Nickel Company of Canada, Limited, stainless steels account for 30 per cent. of total nickel consumption, engineering alloy steels for 17 per cent., electroplating 15 per cent., copper-base alloys 6 per cent., cast irons 5 per cent. and jet-engine alloys 5 per cent., leaving a balance of only 6 per cent. for industrial chemicals and miscellaneous uses. If Cuban production proves fully economic, further expansion of output there may make a substantial contribution towards closing the gap between supply and demand.

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European Engineering Outlook

Investment has been the key to success in Europe's engineering industries in the last few years. *The Engineering Industries in Europe*, published by the OEEC last week, notes that investment has increased continuously since 1952, and on present trends will continue to rise in 1956. To investment is attributed the great expansion in production and improvements in productivity which have led, despite rising raw material prices and continuous wage increases, to prices of engineering products being held remarkably stable against considerable pressure from costs. Helped by easier supply conditions starting from 1953, and reinforced by the considerable increase in demand for consumer durable goods, a high level of investment has developed which has enabled production to rise by over one-third between 1952 and 1955. Meanwhile exports increased so that in 1955 38 per cent. of the total value of all visible exports to non-member countries was accounted for by engineering products, which also made up 30 per cent. of exports by OEEC countries to the dollar area. "It is just to say," comments the report, "that the improvement of the overall economic situation has, to a considerable extent, been influenced by the momentum the economy received from the engineering industries."

The United Kingdom was still the largest exporter of engineering goods in 1955, accounting for 47 per cent. of total European deliveries overseas. Germany with 20 per cent. and France's share of 13 per cent. are a long way behind (although intra-European trade has become the perquisite of Germany). But Britain compares unfavourably on investment—the main factor contributing to success elsewhere. After the war, it was acknowledged that Continental countries, recovering from war-time ravages, would show a very much larger increase in investment than the U.K. for some years. Seven years after the war, however, by 1952, investment in German engineering industries was rising rapidly and has since increased by 50 per cent., while the British increase over that period is less than 25 per cent. Meanwhile in Sweden relatively unaffected by the war, investment expanded by 42 per cent. between 1952 and 1955.

While orders at the end of 1955 suggested that 1956 would be another good year, it is pointed out that reserve capacity is becoming smaller, that there is a growing and acute shortage of skilled labour, and that the supply of engineers and technicians is critical.

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Mission on Heavy Machinery

A mission to India on the further expansion of heavy machinery manufacturing capacity is to be sent under the joint auspices of the Colombo Plan and the Federation of British Industries. The mission will concentrate attention on the aims of the Indian Government for the second five-year plan. In view of the recent success of the steel mission from the United Kingdom to India and the success of Associated Electrical Industries Limited in obtaining the position of consultants to the Indian Government on the development of the electrical engineering industry, the prospects for this new mission would appear to be good. They can certainly draw upon the experience of the previous two missions in handling a delicate situation.

Others are in the field however. A Japanese delegation is shortly leaving for India under the auspices of the Japanese Federation of Economic Organisations. The team will include industrialists from the iron and steel industry as well as from a wide range of engineering activities including shipbuilding. It will be recalled that Japan has had a number of recent successes in the Indian market, and it was recently announced that India is now Japan's best customer for iron and steel products. Competition may also come from the United States and West Germany.

Strategically, this new mission from the U.K. is of vital importance. To-day, high-powered and perhaps somewhat cumbersome delegations of business men have to negotiate basic agreements with socialised states as a means of gaining an initial foothold for a wide range of subsequent orders. Unfortunately, the days when a number of British concerns could win a range of contracts by themselves and so establish personal relationships on the spot which would ensure several generations of goodwill have unfortunately gone for good. To-day, the technique is much more for the big battalions, and the winner takes all. The prizes are commensurably larger and the risks correspondingly greater.

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Coal at a Profit

There is no record that Mr. Micawber found the solution to his personal problems in the coal industry, but to judge from the latest news, he might well have done so. In the course of one week the National Coal Board has both achieved a margin over its expenditure and has decided that nothing out of the ordinary is likely to turn up—at least not for 12 months.

In the first quarter of this year the National Coal Board made a profit of £6 million to reduce its accumulated deficit since nationalisation to £30·5 million. There was a gross surplus of £12·5 million but a loss of over £6 million on imported coal took about half this margin, and provision had also to be made for interest payments and taxation. These results were expected, for it had been anticipated that although a profit would emerge, it would not be as large as the one in the previous quarter owing to the wage increase awarded in February. On the other hand, the results did not benefit from the price increases which took effect on June 1. Total costs per saleable ton increased during the quarter, but there was a noticeable improvement in output due to a sharp fall in the number of man-days lost through strikes. Thestrike figures are still not good, but they are very much better than in the corresponding period of 1955. The least satisfactory side of the picture is the continued poor manpower and absentee figures, and there are now signs also that the investment programme is lagging behind schedule.

The National Coal Board has followed the example of the Central Electricity Authority and pegged its prices. It has announced that unless something "quite unexpected or exceptional" occurs the price freeze will last for 12 months. It is not difficult to surmise that the unexpected would be a further increase in wages, although this would certainly not be a surprise and not many outside the coal industry would go so far as to say that it is unexpected. The coal industry is in a fairly strong position to peg its prices at the moment, contingencies about wages apart, since prices were raised on June 1. It is by no means certain, therefore, that the industry has imposed a very severe discipline upon itself.

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Colleges of Advanced Technology

The Government have selected eight of the ten "colleges of advanced technology" which, with the benefit of increased grants, are intended to provide industry with the much-needed engineers having the highest technical-academic qualifications. The colleges so far designated are: Birmingham College of Technology; Bradford Technical College; Cardiff College of Technology and Commerce; Loughborough College of Technology; Royal Technical College, Salford; and, in London, the Battersea, Chelsea and Northampton Polytechnic Institutes. Two more are soon to be chosen, one in the North-East and one in the South-West where the Bristol College of Technology is the most likely choice.

The conditions required of the colleges demand that they shall each have a governing body that includes strong direct representation from industry and are advised by a committee drawn particularly from industry and the appropriate professional bodies. Teaching conditions are to approximate to those existing at universities and the staff are to be given opportunities for research and consulting work; an adequate library and facilities for private study have also to be provided. Finally each student should, if practicable, spend at least one year of a full-time course or one session of a sandwich course in residence at the college.

There can be little doubt that the chosen colleges do already fulfil these requirements in general terms, though none of them will do

The **Royal Military College of Science at Shrivenham, Wiltshire. (See "Science Under Arms.")**

that there is room for improvement. All of them, particularly Northampton and Battersea Polytechnics, have remarkably fine records in obtaining internal or external degrees of the University of London, especially Battersea whence a regular stream of post-graduate students, many part-time, have successfully presented themselves for higher degrees. The Polytechnics—as well as some of the other colleges—have long been staffed by "recognised teachers of London University." One at least, that at Birmingham, has for some time been very successfully undertaking research and development work for smaller firms who have either insufficient premises or staff themselves. True, few of the designated colleges have sufficient hostel accommodation to be able to offer the advantages of residence for even the proportion of student life that is recommended, but it is to be hoped that now the colleges have acquired this status the opportunities available will be open to the best students in their localities and not—as has been an ugly tendency recently—to deny some whose parents resided on the wrong side of a civic boundary.

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Science Under Arms

Archimedes' contribution to the defence of Syracuse in 215 B.C. or thereabouts demonstrated, though not perhaps for the first time, the value of the scientist in war. To-day no-one would doubt it. It is therefore not surprising that the Army has an institution of university calibre for providing the technical and scientific instruction which must become an increasingly important part of modern military training.

Recently, the Royal Military College of Science at Shrivenham in Wiltshire held an open day during which its extensive and well-equipped premises were viewed by representatives of industry and the Press. The College, which in many respects—though not, of course, in diversity of study—resembles a university, is intended as a "centre of research into the sciences and technologies appropriate to the equipment of the Army and . . . of study and information concerning the further application of science to purposes of war." The instruction provided includes courses leading to degrees in science or engineering of the University of London; technical staff courses; courses in guided weapons and nuclear technology; and courses for General Staff officers. There is considerable liaison with the other services and various outside organisations; Naval and Air Force officers, for example, and civilians holding Ministry of Supply studentships may attend courses at the College. To indicate the range of work carried out the following subjects are a few of those covered in the various curricula: ordnance, fire control equipment, explosives, chemical warfare, radar, telecommunications, computers, tracked and other vehicles, bridging, earthmoving and mines. The College has on its staff many well-known civilian scientists and engineers and has in the past been served by, among others, Professors E. N. da C. Andrade, J. J. Guest (Obituary on page 548) and H. C. Plummer.

Research is an essential feature of any institution offering advanced instruction and typical projects at present in progress are concerned with the effect of impeller design on the performance of centrifugal pumps, three-dimensional supersonic flow, shock tube design, new techniques in engineering drawing, plastic analysis of redundant structures, mix properties of vacuum concrete, stability of footings, the ultimate strength of thick-walled cylinders, and various aspects of electronics and nucleonics. A recent addition to the College is the Rutherford Laboratory in which students receive instruction in nuclear science. The laboratory is well equipped with instruments, remote handling equipment and radioactive sources for experimental purposes.

It can be certain that had Archimedes had access to the technologies taught at Shrivenham to-day he would have wrought havoc with the Roman besiegers.

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Ultra-Low Temperatures

Recent statements by E.I. du Pont de Nemours and Company suggest that major advances are being made in the search for ultra-low temperature refrigerants. Mr. R. C. McHarness of the organic chemicals department told members of the American Society of Mechanical Engineers: "currently available thermodynamic data indicate that new and improved industrial processes and products will emerge as scientists and industrial engineers co-operate in using present refrigerants and perfecting and applying the new ones now being produced experimentally (with boiling points extending over a range of 400 deg. F.)." In his view these developments offer a challenge to engineers in developing new equipment to extend the uses of mechanical cooling in industry. Mr. McHarness had in mind particularly the mechanical limitation of compressors.

Mr. A. H. Lawrence, manager of the technical sales service of the organic chemicals department, pointed out that many of the ultra-low temperature processes were developed during the war. For example, aerosol equipment which is now widely used in the U.S. in the spraying of cosmetics, shaving cream, and innumerable other domestic applications, was developed during the war for spraying insecticides; the cold treatment of special alloys to produce tougher aircraft and tank parts is now being applied to automotive parts and circular-saw blades. Mr. Lawrence commented: "With the continuing development of refrigerants and the continuing development of compressors and auxiliary parts, there is little doubt that the low-temperature refrigeration industry will have the same proportionate growth in the next 25 years as we have seen in the last 25 years for the higher temperature refrigeration and air conditioning industry."

From the engineer's point of view the most interesting developments are the use of ultra-low temperature quenching baths, which enable some materials to withstand higher temperatures. Certain types of steel with controlled crystal formation have already been produced in this way and have exhibited marked improvement in hardness, toughness and dimensional stability. Ultra-low temperatures have also a large potential for the storage of natural gas in its liquid form and in various aspects of nuclear research. In this country ultra-low temperature freezing of mercury is employed very successfully by Sankey-Telcon Limited of Crawley, using I.C.I. refrigerants (Octon 6 and 9). Progress is doubtless required here, as in the United States on the design of new cascade and multistage refrigeration systems.

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Resilient Rubber

Whether one takes as the criterion the Monopolies Commission report on rubber tyres, the decision to embark on synthetic-rubber production on a large commercial scale in this country or the continued good results of the Dunlop Rubber Company, Limited, 1955 was an eventful year for the rubber industry. Last week, the financial results of the Dunlop Rubber Group for the year ended December 31, 1955, were published and showed a net trading balance of £17·5 million, compared with £17·7 million in 1954. During the last year, sales to customers were £219 million, an increase of 15 per cent., and it is estimated that the volume of sales increased by 6 per cent. The inability of the higher turnover to find reflection in the net trading position was due to rising costs, notably the higher price of natural rubber. The profit margin for the group as a whole fell from 6·2 per cent. in 1954 to 5·3 per cent. last year after deducting all charges except taxation. Expansion continues to be the keynote of the industry. The Dunlop Group themselves increased capital expenditure from about £9 million to over £12 million last year and the number of employees increased from about 41,000 to 46,000. Such were the results for the dominant member of the rubber industry, whose activities now range from natural rubber plantations in Ceylon and Malaya to cotton mills, and cover a wide range of finished rubber goods as well as tyres, including footwear, belting, sports goods and latex-foam products. Recently too, Dunlop has become a member of the synthetic rubber consortium, called the International Synthetic Rubber Company.

The North British Rubber Company is also spending considerable sums on expansion. This company, which is closely associated with the United States Rubber Company, now makes U.S. Royal and Fisk tyres. In addition, the company has recently reviewed the prospects for rubber goods as a whole and has decided that the broad field of synthetics and plastics offers further promise. £3 million is to be spent on modernising equipment. The production of rubber footwear has now been concentrated at the Dumfries factory, leaving the way open to changes at Edinburgh, where a new building of 145,000 sq. ft. is to be erected.

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Portable Tool Industry Expands

Since the end of the second World War, there has been a striking increase in the sales of portable electric tools, in particular the "utility" ranges designed for the home handyman. In the past 12 months, for instance, Black and Decker, Limited, have more than doubled the number of tools, of all types, which are sold, while in the "utility" field the number of units sold in the last quarter of 1955 was considerably more than double that in the same quarter of 1954. At the same time, export sales have expanded steadily over the past few years, and Black and Decker are currently supplying about 60 markets. In the industrial field, the steady rise is due to the greater use of portable power and the wider use of portable generators, which has brought the use of portable electrical tools within the scope of builders, civil engineering contractors and farmers—a development which is expected to continue.

To cope with the rising production of tools, Black and Decker have recently expanded their factory at Harmondsworth, Middlesex. The original factory, erected in 1940, was a single-storey building with a total floor area of 80,000 sq. ft., housing the entire production plant, auxiliaries, and office under one roof. This building has now been structurally extended by

building on to it at two adjacent sides, and the factory floor space now amounts to 120,000 sq. ft. The whole of the flooring of the main factory area, a steel-framed single-storey structure, is of reinforced concrete, laid in slabs with expansion joints between. A section of this has been separately laid to carry 60 ton presses. Here the concrete is double-reinforced, and is laid on cork slabs to damp vibration.

Besides extending the production space, the main administration block, which runs along one side of the production area, has been extended, and at the west side of the factory a new polishing shop and a new canteen have been erected adjoining the main structure.

For heating the increased factory space, the boiler house has been enlarged and now has three instead of two oil-fired Davey Paxman boilers. The heating system has been extended; the offices are served by radiators and the production space and canteen by hot-air fan units. The electrical services throughout the production area are carried below the roof in continuous trunking hung from the trusses. This has been done to gain flexibility in the factory layout, so that if the arrangement of the production lines has to be changed, re-wiring can be achieved with the least difficulty.

The accompanying illustration shows the new motor-assembly line in the extended factory.

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Colonial Engineering

Partly, possibly, as a result of two world wars, and largely as a result of the development of means of communication, many undeveloped countries, having learned much of the ways of the West, are now demanding full independence. A contributing factor has certainly been the education of selected individuals in Europe where they have imbibed, not only technical or scientific knowledge, but also political and sociological ideas. This demand has fallen on the United Kingdom with particular weight, owing to the extensive range of colonial territories included in the Commonwealth. Under modern conditions, the prosperity of any country is to a glare extent determined by its state of engineering development; even agriculture, the main industry of most of the Colonies, can only be extended and its practice improved by river training, land drainage, road and railway construction and other civil-engineering works.

In view of these circumstances, the Conference on Civil Engineering Problems in the Colonies, arranged by the Institution of Civil Engineers and held from June 18 to 22, should prove of considerable value. This is the fifth conference of the type to be held; at this latest one, papers relating to works in East and West Africa, Malaya, Nigeria, Aden, Rhodesia and Kenya, were read. Colonial civil-engineering works may frequently present problems not likely to be met at home, and engineers who may have to concern themselves with other Colonial schemes are likely to profit from the Conference. No doubt prominent individuals in some of the Colonies would like to see major civil-engineering works carried out by their own nationals, but those with technical rather than political training will know that this cannot happen for many years. A wide field for British engineers should long endure, but a matter of vital importance is that those who devote themselves to work in these territories should have security of tenure. This is just as important for the welfare of the colony as for that of the individuals concerned.

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Agriculture in Northern Rhodesia

The proposed sale of the Trinidad Oil Company has given rise to much heart-searching regarding the ability of this country to finance development in the Colonies. It is therefore encouraging to be able to record a further contribution by the Selection Trust group of companies to the general economic development of the Central African Federation. It was announced recently that Rhodesian Selection Trust Limited, are proposing to set up a pilot farm on the Kafue Flats in Northern Rhodesia. This follows the decision of the Selection Trust group to assist in financing the Kafue hydro-electric scheme and their participation in the establishment of the Merchant Bank of Central Africa.

Hitherto, the number of European farms in Northern Rhodesia has been small and the wealth of the country has been derived almost entirely from the copper mines. The Kafue Flats comprise an area of 1,300,000 acres along the banks of the Kafue river, subject to annual inundation when the river is in flood. A report has been prepared by consultants appointed by the Rhodesian Selection Trust group and this envisages the creation of large polders on the Dutch plan intersected with canals and cut up into farms of about 160 acres for European settlement, with smaller farms for an African settlement scheme. Very little, however, is known about the soils in the area and the first step will be to establish a pilot scheme and operate this for a period of some years.

If this scheme is successful, it would be necessary to build a dam to control the Kafue river of which the flow, when controlled, is estimated at about 6,000 cub. ft. of water per second. Assuming that half this might be required for hydro-electric power, the balance would be sufficient to irrigate about 450,000 acres. The main crops would probably be wheat, barley and rice, and assuming a rotation comprising three years of crops followed by three years of irrigated pasture for dairy cows, it has been estimated that the value of the return from these 450,000 acres at present prices might be £30 million a year.

The new motor-assembly line in Black and Decker's extended factory for portable electric tools, at Harmondsworth.

This may well lead eventually to the establ ment of secondary industries based on agr tural by-products, and the opening up of a n market for agricultural machinery.

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Manufacturing Industry in Australia

Output of manufactured goods in Australia during the six months to April, 1956, was the highest in the country's history. This was particularly true in the case of machinery and industrial plant. The latest *Survey of Manufacturing Activity in Australia*, published by the Industries Division of the Ministry of Trade, contains a warning that the rate of expansion has slowed down in recent months and is not likely to increase during the winter. As in this country, the high rate of taxation, the increase in the sales tax on motor cars and a credit squeeze—perhaps milder than we have experienced here—have caused a fall in the output of consumer durable goods and motor vehicles.

The demand for machinery and equipment has reflected the strong upward trend in public and private investment. This tends to be concentrated in heavy industries, although plastics, electrical engineering and motor vehicles all expanded capacity.

The *Survey* states that import restrictions " have not of themselves resulted in any substantial increase in manufacturing output " and points out that their main influence lies in reducing the rate of expansion of manufacturing industry " more particularly by limiting the availability of plant and equipment." The Minister of Trade, Mr. McEwen, stated that manufacturers have a major contribution to make to the country's economic problems by " thoroughly exploring and exploiting export possibilities," by increasing capacity for basic materials and equipment and by conserving goods in short supply. When the *Survey* was published manufactured goods (excluding processed foodstuffs and refined metals) represented less than 10 per cent. of Australia's total exports.

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More Cold Comfort

The remarks made by Mr. O. C. Turner, chief executive and general manager of Qantas Empire Airways discussed in a Weekly Survey of June 22, have been underlined by two developments during the past week. These are the further delay in the introduction of the Britannia by B.O.A.C. and the announcement that the Convair Division of the General Dynamics Corporation are to proceed with building the Convair Skylark 600, now renamed the " Golden Arrow."

The Britannia which was intended to be brought into service in July, is now not likely to be available until October and no definite announcement can be made until the end of July.

The introduction by Convair of the " Golden Arrow " is a further example of the advantages enjoyed by American aircraft manufacturers in having a large home market available to them. The company had previously stated that they would not go ahead with construction of this airliner unless they received orders for at least 40. These orders have now been obtained, 30 from Trans World Airlines and 10 from Delta C. and S. Airlines, a United States domestic operator. The new aircraft will have four CJ-850 engines, the commercial version of the General Electric J-79 military jet engine. This represents the first entry of General Electric into the commercial engine field after building over 30,000 military jet engines. Delivery is scheduled for late 1959 and this will increase still further the competition which British manufacturers must expect to meet in long-range civil aircraft.

We regret that in the Weekly Survey note about Qantas Empire Airways, Limited, published last week the company's name was given incorrectly.

THICK AND THIN SANDWICHES

As in so many educational matters Scotland led the way in the introduction of sandwich courses, for they have apparently been in operation in Glasgow for over a hundred years. In England the B.T.H. and G.E.C. companies were among the pioneers in their use in the training of their apprentices, and they have been in operation in one or two English colleges; but their extensive introduction is a matter of only the last three or four years. In the academic year 1954-55 there were 41 technical colleges in England and Wales with sandwich courses in engineering and other technologies, and 1,522 students were taking them. Now they have been made the keystone of the arch of the new policy for technological education for they are to comprise the bulk of the courses in the Colleges of Advanced Technology envisaged in the Government's White Paper on Technical Education.

A sandwich course is the name given to a system in which full-time periods of academic education are arranged alternately with similar periods of industrial training. In this sense even part-time day release is a sandwich course but, with the increasing complexity of modern technology, this has long been recognised as an inadequate system of training for professional engineers and senior technicians. The B.T.H. Company, for example, which started with releasing its apprentices to the College of Technology at Rugby—the only town where the provisions of the Fisher Act for compulsory day release were brought into operation—found it necessary to extend the period bit by bit until periods of six continuous months at college were introduced. To-day there are many different types of course in which the sandwich can be "thick" or "thin" but, for advanced work, periods in college of at least half the year are generally considered necessary. In an appendix to the White Paper, the National Advisory Council on Education for Industry and Commerce state that sandwich courses already in being at a number of technical colleges cover periods from two years leading to the Ordinary National Diploma to four or five years leading to the Higher National Diploma and College Associateships. They recommend that the professional course should normally cover the latter period with preferably five months in college alternating with seven months in works; although the needs of particular industries and the need to even the load in the college and in the works may require this to be modified.

NON-UNIVERSITY SIXTH FORMER

At a recent conference organised by the Ministry of Education and the British Association for Commercial and Industrial Education, Mr. F. Bray, the Under Secretary at the Ministry in charge of Further Education said that they were looking to the sandwich course first as a means of raising the standard of the good part-time student, and second as a means of attracting the non-university sixth former into industry. On the assumption that a third of those at present taking the Ordinary National Certificate and a sixth of those leaving sixth forms of grammar schools and not proceeding to a university are suitable for a professional course, the potential source of students for these courses is of the order of 4,000 to 5,000 a year. One of the advantages of sandwich courses from the Ministry's point of view is that, where the firm pays both the fees and wages, there is less demand on public funds, although there was some disagreement with Mr. Bray's view that the net cost is a tiny fraction of a firm's budget There are also the advantages that the apprentice will have roots in the firm and all the students will be treated alike financially, which is not always the case where assistance is provided by local education authorities. Although this may be the case in a particular firm, examples were given at the conference to show that the practice of different firms varies widely.

From industry's point of view the advantage of the sandwich course, apart from increasing the number of trained men available, is that it provides a form of training particularly suitable for those going on to the production side, to which it is often difficult to attract the university graduate. As Mr. G. S. Bosworth of the English Electric Company pointed out, there is a strong inclination among university graduates towards research and development, and some persuasion may be needed to get the more able men to undertake the necessary training and instruction for manufacturing after they have completed a formal course. The young man who enters industry straight from school, even at eighteen, is not so worried about his status as the university graduate, nor about the fact that the knowledge which he has already gained is not of immediate application. He has some time in which to settle down and decide what sort of job he wants to do and what sort of knowledge he will require for it.

PRACTICAL EXPERIENCE

According to Dr. P. F. R. Venables, of Salford College of Technology, this makes for an easier transition than normally from full-time study to employment, enabling the employer and the student himself more surely to test his aptitude for an industrial career through the system of selection through training. Although there is a general opinion in industry that some practical experience before academic training assists a young man to make sure that he wants and is suited to an engineering career and sends him up to the university or technical college as a more mature student, not all firms agree that the normal sandwich course is the right method of training. The alternative, which might be described as a "thick sandwich" scheme, is to provide—in place of the present more general three-year university course followed by two years graduate apprenticeship—a year's pre-university industrial training and a post-graduate year of specialised training after the university course. To some extent the choice must depend on the standard which is being aimed at, and here there is still a great deal of confusion. Taking only the full-time or sandwich courses for technologists of professional standing, the awards which may be obtained at technical colleges at present include the external B.Sc. degree of London University, the Higher National Diploma, and the diplomas and associateships of particular colleges. The Hives Council has now announced the conditions for the new Diploma in Technology which is to be of a standard approximating to an honours degree at two levels, with the possibility of an award at pass level for those who fail to reach the higher standard. A course for such an award, with a substantial grounding in basic science and mathematics and with a broad general curriculum, could not be of less overall duration than a university course. Mr. Bray even suggested that it might well be desirable for the sandwich student to spend some 100 weeks in college compared with about 80 spent by the university graduate. If anything like this standard is established, it is clear that the number of colleges that will be capable of providing the quality of tuition needed for it will be very limited, and the official view that courses in a fairly large number of technical colleges, some of them part-time, will qualify is unlikely to be realised.

HIGHER NATIONAL CERTIFICATE

Assuming that the external degree and the H.N.D. are superseded by the Dip. Tech. (Eng.), the question that will then arise is what is to happen to the Higher National Certificate which is to-day largely used as the channel to professional qualification.

That the present position is one of flux can be seen from the varying arrangements at present in operation by the big firms. The framework of apprenticeship schemes is to-day a fairly common one, although the nomenclature may vary, and it generally covers three levels: craft, student and graduate. This does not, however, lead to a rigid demarcation between craftsmen, technicians and professonal engineers, because there are generally ladders of promotion from one stage to the next, and the grade of technician covers both promoted craftsman and some student apprentices. It is not surprising that such advanced industries as aircraft and electrical manufacturing and chemical engineering should have produced the most elaborate schemes. Rolls-Royce, for instance, apart from trade apprenticeships, offer student apprenticeships leading to Higher National Certificate, engineering apprenticeships to external degree, university "thick sandwich" apprenticeships for state-aided or private students, and graduate apprenticeships of the normal two-year post-university period.

At the Bristol Aeroplane Company all apprenticeships other than for graduates are of the sandwich type. The two trade apprenticeships courses (Course A being training in a single craft and Course B a more general training for advanced tradesmen and technicians) including one full week in every four weeks at the Company's school to study for a final City and Guilds or Higher National Certificate; and the Aeronautical Engineering Apprenticeship (Course C) has alternate six months spent in industrial training and in full time study for the Higher National Diploma. The Undergraduate Apprenticeship (Course D) has works periods of one year before and eight months after the University Degree Course and during vacations.

Vickers-Armstrongs offer engineering apprenticeships of normal type leading by part-time study to the H.N.C., but outstanding apprentices can go on to sandwich courses leading to the diploma. In addition there are various types of sandwich courses leading to a degree.

COLLEGE COURSES

The B.T.H. student apprenticeships lead by four-year sandwich courses to professional qualification or by part-time study to the H.N.C. This year a five-year sandwich course is being introduced which should lead to the new Dip.Tech. and will replace the London External Degree course. Metropolitan-Vickers are now offering up to 80 a year of their most suitable student apprentices sandwich courses leading to the H.N.D. in place of the normal H.N.C. by part-time study. The British Oxygen Engineering Company has a number of sandwich-course apprentices taking courses leading to the H.N.D. in mechanical, production and chemical engineering, and offers two scholarships a year to outstanding apprentices to go to the Imperial College. Rather late in the field are British Railways who have so far relied on a very small proportion of professional engineers, and most of those men who had acquired their status through the H.N.C. They have now made arrangements with Derby College of Technology for a sandwich course leading to the I.Mech.E. examination and looking to the new Dip.Tech. in the future. They have also arranged with Southampton University for a five-year degree course in civil engineering consisting of alternate periods of nine months in university and 15 months in industry. The National Joint Advisory Council of the Electricity Supply Industry has just agreed to recommend to Electricity Boards, in addition to the present arrangements for part-time release for courses leading to the H.N.C., a system of sandwich courses to lead to the H.N.D. These will vary according to local conditions, but it is suggested they should normally be of four years' duration with six months' alternating periods in college and industry, and with preliminary and final periods in industry. In addition, the Authority offers a number of scholarships to the universities. In the iron and steel industry, Dorman Long for some years before the war had sandwich course arrangements with Constantine College, Middlesbrough, and so have Colvilles with the Royal Technical College, Glasgow. The industry has also now made arrangements for Dip.Tech. courses to be held at Battersea Polytechnic.

Although there are undoubted advantages

in a system as varied and flexible as these arrangements disclose, there are also serious disadvantages. It is difficult for the boy leaving school to know at what he should aim, and it is equally difficult for a prospective employer to know what value to put on the award an applicant has obtained. Presumably the Dip.Tech. will take the place of the H.N.C. and the H.N.D., and possibly also of the London External degree, as avenues to professional qualification, but if its standard is to be that of an honours degree there may still be need for some award between it and the Higher National Certificate, limited as the standard of the latter must be by the inadequacies of part-time education. It is not only for professional engineers of the highest grade that part-time education is to-day insufficient, for many of the increasing number of technicians (including design draughtsmen) by whom they must be supported will also need a more substantial grounding in engineering science than it can give them. It may be that for this purpose the H.N.D. will remain the appropriate award, although it might be more satisfactory to provide a separate Dip.Tech. at pass level similar in character to an ordinary degree.

BUREAUCRATIC IN-BREEDING

The works-based sandwich course is obviously difficult for the smaller firms to provide, and the answer to their problem must be group apprenticeship schemes of the admirable type being developed in the London area by the Engineering Industries Association in collaboration with a firm of consultants. They provide craft, technician, student, commercial and graduate apprenticeships, with the advantage that the apprentice will receive his practical training in a number of different firms. So far no sandwich-course schemes have been started, but it is expected that, as the need for better educated and qualified staff becomes more recognised, the demand for student apprenticeships of this type will develop.

The majority of sandwich-course schemes so far envisaged are works based, and this might have disadvantages from the point of view of the variety of experience of the young engineer and his occupational mobility. It used to be said that the aspiring engineer ought to have had five jobs before he was thirty, but the growth of elaborate technical and managerial training schemes, as well as pension funds in large firms, may produce a sort of bureaucratic in-breeding. The only answer to this danger is the greater provision by the State and local authorities of grants for college-based students, and the willingness of industry to accept them for their periods of works training. The disadvantage is partly offset in the case of some large firms who use one college but send apprentices to many different works throughout the country.

We are here on the threshold of a substantial change in our methods of training engineers and other technologists. This change is being born of a marriage of convenience between industry's need and Government expediency, based not on confirmed desire or experience but on a hunch. Industry believes it wants more professional engineers in managerial and production posts (sandwich courses should also produce men for design and commercial positions where the need is even greater), but it is not satisfied that the present methods of training, whether in works or university, are entirely satisfactory. The sandwich course is to some extent a compromise, but it is so far largely untested and there is a strong case for an attempt at a serious research study into methods of engineering education and training along the lines of the proposal recently put forward to the Institution of Mechanical Engineers by Mr. P. P. Love. It is a little strange that an industry increasingly based on scientific knowledge and research should stumble so blindly forward in the main activity on which the application of that knowledge will depend.

Since the analysis was made on the assumption of "perfect" beams it had been necessary to introduce corrections to allow for imperfections in workmanship, such as initial curvature and twist.

FACTORS OF SAFETY

The factors of safety given in the revised Standard were based on the theory of probability for various conditions of loading, and the results had been compared with those stated in the Report of the Committee of the Institution of Structural Engineers on Structural Safety. These factors were to be used in conjunction with either the yield stress or the buckling (or lateral instability) stress in order to arrive at the permissible design stresses. The results of tests on models and on full-size girders were reviewed in the light of any imperfections in each case.

Web stresses were considered in the succeeding section of the paper and a distinction was drawn between thick or stocky webs, where shear yield was the criterion, and slender webs which would buckle before the shear yield stress was reached. In the latter case the theoretical critical stress had been derived from Timoshenko. The effects of shear stresses in excess of the critical value and of membrane stresses on stability were also examined. It was pointed out that local failure may occur without the collapse of the whole web. Design formulae were given for the cases of pure shear or of shear combined with bending; in the latter case the Huber-von Mises-Hencky theory was quoted to justify the high equivalent direct stress permitted at the junction of the web and flange. A maximum or "ceiling" value for the stress, equal to the shear yield stress, was stated for each case. The effect of stiffening the web by vertical stiffeners only, or by horizontal as well as vertical stiffeners, was considered, and limiting slenderness values of the web given for each case, as well as for unstiffened webs. It was noted that intermediate stiffeners were to be designed to restrain the web plate against buckling and that their stiffness was to be related to that of the web panel and to their spacing. Reference was also made to the effect of membrane stresses on the stiffeners. The effect of bending stress on stiffeners was also dealt with, and tentative rules given for the stiffness of horizontal stiffeners when used singly or otherwise. Tests on web plates were also discussed in this section of the paper.

The latter part of the paper was devoted to the application of the new rules to design, to the economy to be obtained by their use, and a statement of some of the proposed clauses for working stresses in flanges and web plates. Numerical design examples were given, as well as appendices showing the derivation of the formulae for top-flange loading and flange-plate curtailment.

TESTS ON MODELS

The second paper dealt almost entirely with the preliminary tests on model girders and the later tests made at the Military Engineering Experimental Establishment, Christchurch, on full-size girders. These tests were carried out during the drafting of the revisions as a check on the proposed rules. The model tests were carried out mainly to check the limits laid down for the slenderness ratios for unstiffened and for stiffened webs.

A second series of tests was carried out on girders up to 75 in. deep using the 250 ton testing rig at M.E.X.E.; the rig was briefly described in the paper. These later tests were used to check for flange stability, web buckling, and the combined effect of shear and bending, and were reported at length, the load factors being given in each case. The paper also gave design rules for the "plastic" analysis of girders with thick webs of the type referred to in the previous paper.

DESIGN OF PLATE GIRDERS AND BEAMS

SOME IMPLICATIONS OF THE NEW B.S.153

The recent alterations made to B.S.153, Girder Bridges, Part III, Loads and Stresses, with special reference to stresses in beams and plate girders, were dealt with in two papers*† presented to the Institution of Civil Engineers for discussion on February 28.

As some of the authors of the first paper were members of the drafting panel for the revised Standard, which has now been circulated in draft form, the paper was valuable in explaining the differences between the revised and the original (1937) edition. The new draft is, of course, radically different from the old edition, being based on analytical rather than empirical methods. The authors pointed out that economy in material might be obtained by judicious use of the revised clauses, but it would appear that the work of the designer might be increased in view of the rather complex nature of some of the rules. It was worthy of note, however, as one speaker pointed out, that only in certain cases would it be necessary to apply the rules—which were most involved—for lateral instability of compression flanges, since the designer would normally guard against this by providing some effective support.

The first of the papers, by Kerensky, Flint and Brown, discussed the design of beams and plate girders with stocky or slender webs and with flanges which might be equal or unequal; the effect of curtailment of the flange plates was also examined. The earlier part of the paper was devoted to a discussion of the stresses in flanges and, in particular, lateral instability. The work of Timoshenko, Chwalla and other authors was quoted and a general expression for the critical bending moment for beams stated; a similar expression for the critical bending stress in the case of cantilevers was also given.

The general expression for the critical bending moment for beams was modified to a more useful form applicable to a wide range of symmetrical sections (neglecting imperfections). This expression was then further modified to deal with cases where the flanges were unequal.

The case of top flange loading, i.e., loads free to move sideways, and its effect on the critical stress was considered, so enabling expressions, sufficiently accurate for design purposes, to be stated for the effective lengths of the compression flange. It was pointed out that, when in addition to top flange loading the compression flange was smaller than the tension flange, the critical bending stress was seriously reduced.

Curtailment of the flanges had been found to necessitate a modification to the lateral buckling clause on account of the reduction of the torsional and flexural rigidities near the supports, and a formula was put forward to cover the cases for change in thickness or in width. The effects of restraints on stability were considered and the effective lengths of the compression flange stated in terms of the spacing and stiffness of the supports, but part of this section of the paper was somewhat obscure. It was pointed out that stocky webs might fail by yielding before lateral instability of the compression flanges developed (this point was considered at more length in the second paper).

* "The Basis for Design of Beams and Plate Girders in the Revised British Standard 153," O. A. Kerensky, Dr. A. R. Flint and Dr. W. C. Brown.

† "Experimental Verification of the Strengths of Plate Girders designed in accordance with the Revised British Standard 153: Tests on Full-Size and on Model Plate Girders," E. Longbottom and Dr. J. Heyman.

FLOW SEPARATION AND AIRCRAFT SHAPES

"The Aerodynamic Art" was the subject of the 44th Wilbur Wright Memorial Lecture, given before the Royal Aeronautical Society, in London last month by Sir William S. Farren, C.B., M.B.E., F.R.S., technical director of A. V. Roe and Company, Limited. The main part of the lecture was concerned with the transonic problem and the changes which occur in air flow and pressure distribution round an aerofoil as the airstream speed is increased from subsonic to supersonic. This was illustrated by a film prepared by the Shell Film Unit, as well as by a series of schlieren photographs and interferometer pictures. We give below extracts from that part of Sir William's lecture dealing chiefly with flow separation, and of his concluding section on the changing shape of aircraft.

At a given Mach number, as incidence is increased, strong shock waves are produced by the progressively higher local supersonic speeds, due in turn to the progressively lower pressures over the upper surface as the angle increases and the lift rises. At the larger angles the separation behind the shock wave is gross and there is a wide turbulent wake. There is no apparent separation at or near the leading edge. The local supersonic flow near the nose seems to be able to "turn the corner." Clearly, both the shape of the wing near the leading edge, and certain differences between subsonic and supersonic flow, have strong influences on the way the air behaves in such circumstances. By thinning the shape near the leading edge, and so reducing the radius of curvature of the nose, and at the same time cambering the shape, air can be persuaded to cling to the surface, and the occurrence of appreciable separation is delayed for several degrees.

A rather striking technique for looking at the flow round an aerofoil uses the optical interference between a beam of light that passes across the flow and a reference light beam. The result is a picture of interference fringes which gives an approach to a quantitative outlook on the situation, since the air in each of the fringes shown has a constant density.

In Fig. 1 is an "interferometer" picture of a flow without separation. Figs. 2 and 3, and 4 and 5, contrast the flow round the same wing at 8 deg. incidence at Mach 0·6 and Mach 0·9, by schlieren and interferometer pictures. At Mach 0·6 there is a gross separation at the leading edge, and over the whole of the upper surface of the wing. At Mach 0·9, the flow becomes supersonic round the extreme nose, the radiating fringes being the characteristic sign of a "supersonic expansion" by which, at supersonic speeds, air can turn round sharp corners. The conditions here are substantially those of the "Prandtl-Meyer" flow in truly supersonic flow. The ultimate return of the flow to the general subsonic speed through a complex series of shock waves, and the accompanying gross separation of the boundary layer, is clearly shown. Here it seems rather less formidable than in the schlieren picture.

It seems unlikely that we can ever be clever enough to live with conditions such as are represented in Figs. 2 to 5. The use of such schemes as "vortex generators" to inject energy —clean air—into the boundary layer, and a deliberate shaping of the front of the wing so as to use the ability of local supersonic flow to turn round a sharp corner without separation, coupled with the use of rather thinner wings than those with which we first attacked the high subsonic speed range, may avoid most of the difficulties described. But it does not seem probable that high subsonic separation can be entirely excluded from all the conditions which a transonic aircraft has to meet, and it is necessary, therefore, to consider what is the harm which it might do.

Indirectly, it results in large and undesirable changes in the pressure distribution and forces and, therefore, on the balance and control of the aircraft. The direct harm is vibration, leading possibly to fatigue of the structure. At very high speeds the variations of pressure in a separated flow can be fairly large, and since they repeat frequently, they act rather like a powerful pump going at a high speed. If we cannot eliminate separation entirely, we must control it so that we are sure that there is an ample margin of safety.

Few problems have proved more difficult than the correlation between fluctuating air flow and its consequences to an aircraft. And the measurement of such fluctuations in wind tunnel experiments on models, while possible in principle, is tedious and of limited utility because of difficulties in simulating effects associated with vibration of the aircraft structure. Even the measurement in flight of fluctuating forces, while technically easier because there is space in which to put the necessary equipment, is far from easy to interpret in terms of what can be accepted as tolerable and safe.

In this field, however, valuable advances have been made recently by which we can link up observations of the flow in two dimensions with wind tunnel experiments on two-dimensional models of typical strips of a wing, and on three-dimensional models of the whole wing. These in turn can be related to the characteristics of the aircraft in flight. It has been found possible to cover the full range of angle of incidence (or lift coefficient, or the equivalent g on the aircraft) and of Mach number.

It was assumed that if the onset of separation could be detected, it would be possible to correlate it with the onset of fluctuating pressure on the aircraft and its consequences. Measurements of the pressure on the upper surface of model wings at a constant angle of incidence, showed that the onset of the effects of separation coincided with a marked tendency of the pressure at a point near the trailing edge, after rising steadily as the Mach number rose, to fall suddenly. Fig. 6 shows qualitatively the general character of measurements of this pressure. From this is constructed Fig. 7, a diagram showing the relation between angle of incidence and Mach number at which one might reasonably

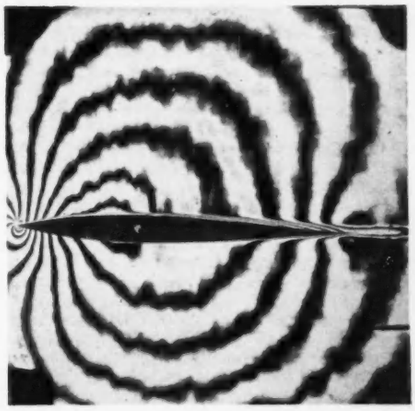
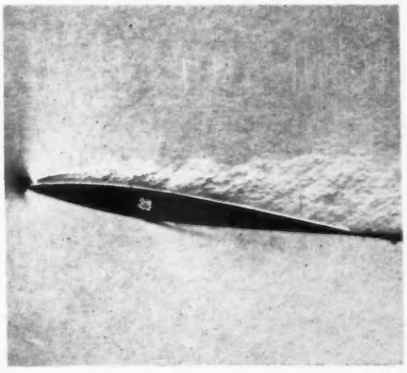
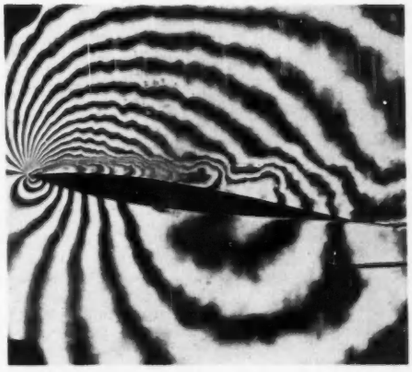
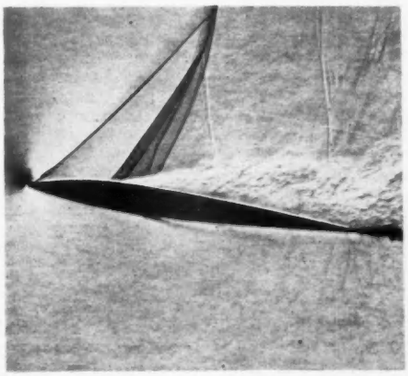


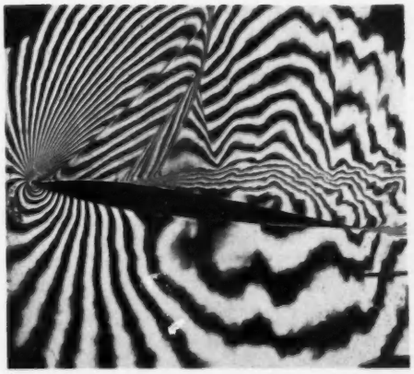
Fig. 1 The flow round a wing at low Mach number and angle of incidence, shown by interference fringes, boundary layer and wake, but no separation.





Figs. 2 and 3 Mach 0·6, incidence 8 deg.





Figs. 4 and 5 Mach 0·9, incidence 8 deg.

Figs. 2-5 Schlieren and interferometer pictures showing the effect of a rise of Mach number from 0·6 to 0·9 on separation at the leading edge. The rise of Mach number has removed separation from the leading edge to the foot of a shock wave at about 30 per cent. chord.

expect the effects of separation to be evident. These measurements could be made at a point along the span of a model where experience suggested that separation was likely to occur. They were compared with observations of the effects of fluctuating pressures in flight, using two different methods which themselves gave remarkably consistent results—measurements of vibration by accelerometers, and observations by observers in the aircraft. The correlation obtained is shown in Fig. 8.

The flight instruments were put in places where, from other evidence, the effects of vibration were most distinct, and were adjusted to a high sensitivity, the object being to detect the first measureable sign of vibration. The human observers were experienced in detecting signs of very slight vibration, far less in intensity than what passes without comment in the majority of aircraft. The background level of vibration in the aircraft used in these experiments was very low.

The fact that these flight observations agree with the curve derived from the wind tunnel experiments, which are in turn consistent with the observations of the effects of flow separation, means that we have now a logical method of attacking the problem, based upon firm foundations.

The next step was to try schemes which would be expected to reduce or eliminate separation, to test them on a model of the complete wing, and in flight. The results were remarkably consistent. There was reason to believe that we had separation "under control."

It is at this point that I propose to leave this subject, but with this last word. It was not until the problem was met, and met in flight, that it was possible to assess how important it was.

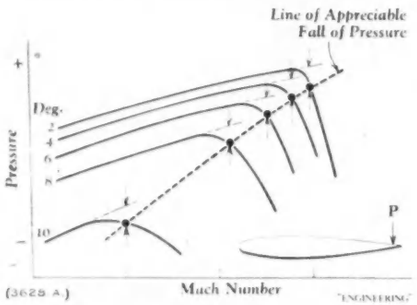


Fig. 6 Variation of pressure on upper wing surface with Mach number, at constant incidence.

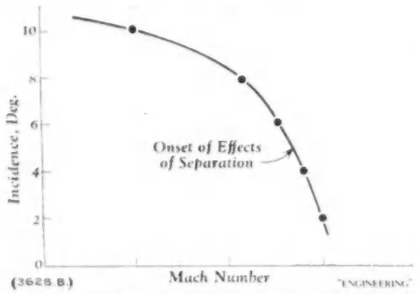


Fig. 7 Relation between angle of incidence and Mach number at onset of effects of separation (wind tunnel).

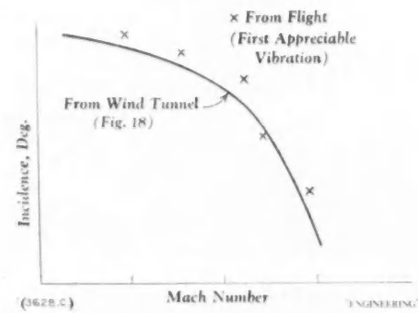


Fig. 8 Relation between angle of incidence and Mach number at onset of measurable vibration in flight.

THE CHANGING SCENE

Fig. 9 is a pictorial record of some typical aircraft. The horizontal scale of Mach number ranges from 0 to 2·0. All the aircraft are drawn to the same scale.

The Spitfire, representative of the "subsonic" days has the lowest touch-down speed shown on the chart. Although not intended by design to exceed about Mach 0·65, it was dived to over 90 per cent. of the speed of sound and survived unharmed. In all respects it was a wonderful aircraft over its whole speed range.

In the second group —"high subsonic"— three examples emphasise the different ways in which engineers have used their art, sometimes puzzling the world by the diversity of their ideas.

The Comet may fairly be described as the crystallisation of 30 years of experience. The Boeing B-47 and the Avro Vulcan are examples of two ways of meeting much the same requirement.

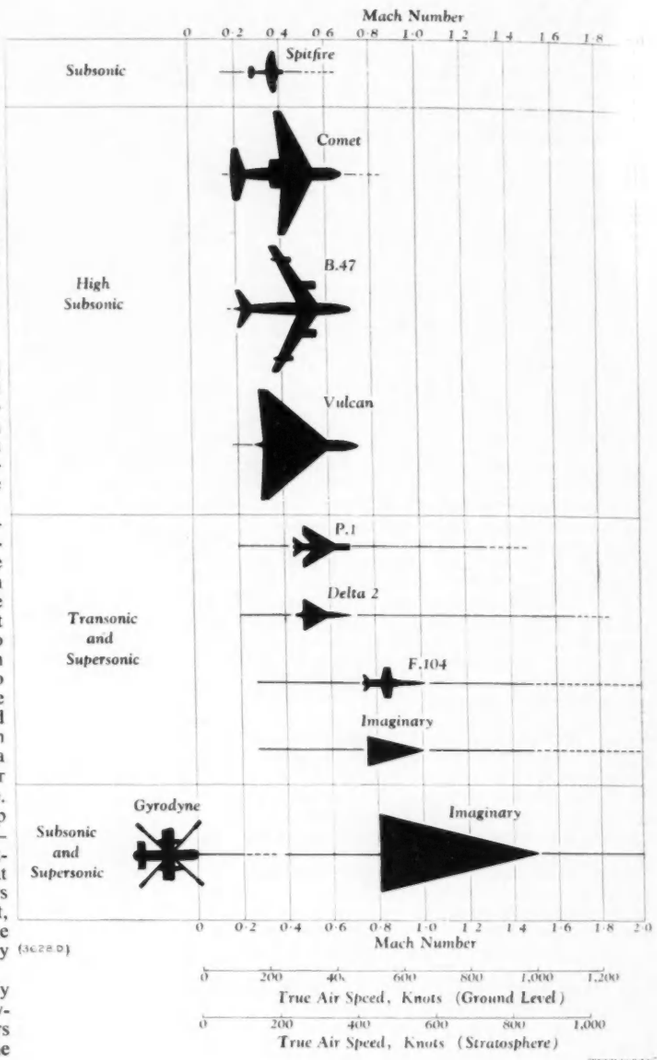


Fig. 9 Shapes in the sky.

In the third group, "transonic and supersonic," are first the English Electric P1 and the Fairey Delta 2. These two aircraft may perhaps serve to illustrate the point that once you have safely navigated the high subsonic region, there is smoother water ahead. It is mainly a question of pushing harder.

I was tempted to put the Lockheed F 104 in a group by itself, labelled "supersonic only," which exposes the difficulty of trying to label things, particularly aircraft. It has a touch-down speed of about 150 knots and must therefore pass through the transonic region, but is probably intended to do so without hesitating.

Below it in the same group is an imaginary triangular shape, included mainly to emphasise that there is still plenty of room for variety of opinion about what shapes might make good aircraft. This third group contains examples of almost every shape that has been suggested so far, except the popular circle. This suggests that there is more than one way of doing this particular job.

The fourth group, "Subsonic *and* Supersonic" emphasises possibly the most important point in the whole diagram. The high speed of aircraft has risen in 10 years from, say, 400 to 1,000 knots. Rocket-propelled aircraft have gone even faster. This advance has, however, been bought largely at the cost of a rise in the take-off and touch-down speeds. The helicopter, the Fairey Gyrodyne, is an example of a flying machine which has an infinite speed range, defined as the ratio between top speed and touch-down speed. To the right of it is an imaginary shape, an enlargement of the one above it, definitely supersonic. The problem seems to be to combine the two, or rather to devise something which will have the qualities of both. We cannot expect to provide an acceptable solution to supersonic transport until we recognise that we have already gone farther than is wise in take-off and touch-down speeds.

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VISCOUNTS FOR LUFTHANSA

The negotiations which have been under way for some time between Lufthansa and Vickers-Armstrongs (Aircraft) Limited, have been brought to a successful conclusion, and the German Airline have signed an order for seven Viscounts of the latest type, with an option on two more. This is the first time that Lufthansa has ordered British aircraft, either since or before the second World War.

Lufthansa's version will be known as the Viscount 814D, and will be powered by four Rolls-Royce Dart R. Da 7/1 propeller-turbines giving 2,100 h.p. each at take off. The cruising speed will be 365 m.p.h.

The new Viscounts can easily be converted at a later date to the still more powerful Dart R. Da 8 engines when these become available, and this conversion will give the Viscount a 400 m.p.h. cruising speed.

The Iron and Steel Institute in France (*concluded from page* 536)

THREE PROBLEMS FOR STEELMAKERS

FURNACE GAS FLOW, SULPHUR AND IMPACT TESTING

Concluding our report of the special meeting of the Iron and Steel Institute, held in Paris from June 5 to 14, we have now to deal with the proceedings of the morning of Friday, June 8, when two simultaneous technical sessions, "C" and "D," were again held at the Chambre Syndicale de la Sidérurgie Française, Rue de Madrid.

AERODYNAMICS OF OPEN-HEARTH FURNACES

"Studies on a Model of the Aerodynamics of a Maerz-type Open-Hearth Furnace with Preheated Gas, and a Comparison with Siemens and Terni Furnaces" was the title of the first paper considered at session C. It was by Mr. G. Husson, of the Institut de Recherches de la Sidérurgie (IRSID), and Mr. G. Cohen de Lara and Mr. R. Durand, of the Laboratoire Dauphinois d'Hydraulique.

The authors stated that at the centenary congress of the Société de l'Industrie Minérale, held in Paris in June, 1955, they had presented a report of results obtained on reduced-scale models of the aerodynamics of a standard Siemens and a Terni-type open-hearth furnaces. The present paper completed this previous work by giving the relative results for a Maerz-type furnace.*

As a result of aerodynamic tests carried out on a wooden model of the No. 4 furnace at Hayange Steelworks, built on a $\frac{1}{10}$th scale, it had been established that the flame of this type of furnace, given uniform excess of air, was much shorter than that of the Siemens and Terni furnaces. The flame of the Maerz furnace was very sensitive to departures from symmetry in the outflow of gas in the uptakes of air and gas burners, or to variations in the dimensions of the furnace.

The research programme of this type of furnace was being pursued simultaneously with that on the other types previously studied. The programme would include a study of the effect of the recuperators and the slag pockets; the effects of the doors and various air inlets which were probably very important owing to the presence of lateral re-circulation currents; and tests in the steelworks on the actual No. 4 Hayange furnace, when cold, by injecting air into the recuperators and furnace chamber.

Much of the discussion on this paper was devoted to the consideration of the effect of a new type of Maerz furnace on the recirculation zone of the furnace. Mr. G. Cohen de Lara stated that in this furnace the walls sloped towards the axis of the furnace and this would tend to favour the stability of the flame and reduce lateral recirculation.

Mr. A. Grosjean said that a 30 ton furnace having inclined walls had been built at the Cockerill Ougrée Works in Belgium and had given very encouraging results both from the point of view of heat consumption and that of increased productivity. Although the furnace appeared unorthodox in shape, it had been decided to build another one like it.

Mr. R. W. Evans stated that at the Steel Company of Wales Limited work had been done using cold models of the open-hearth furnace. Although the importance of this type of work was recognised, there were drawbacks to its application to full-scale operations. If, for instance, heaps of materials were placed at irregular intervals in the model-furnace bath, so as to simulate heaps of scrap, such as would obtain in practice, the results obtained for gas and air circulation were quite different from those yielded from the furnace when the interior was smooth. Moreover in a molten-metal bath the reactions which took place were often violent and these had an effect on the passage of the gas and air through the furnace.

On the other hand, it was quite true that important results could be obtained from cold model work. Recently, model experiments had been carried out on a single-uptake furnace and these had indicated the best cross-sectional area and shape to be given the uptake.

* *Editor's Note.*—The Terni furnace was initiated in Italy but has now been adopted elsewhere. In this furnace the angles and other characteristics of the air and gas ports are designed in such a manner as to obtain intimate mixing of the air and gas and the resultant production of a very hot flame. In the Maerz furnace the air enters the furnace chamber by way of two vertical uptakes situated on each side of the gas port.

DESULPHURISATION WITH LIME

The second paper considered at session "C" was upon the subject of "Desulphurisation of Liquid Pig Iron by Blowing with Lime Powder." It was by Mr. B. Trentini, Mr. L. Wahl and Mr. M. Allard, of IRSID. The authors stated that a characteristic of the new process which had been given special attention was the creation of the very best conditions of contact between the liquid bath of metal and the desulphurisation agent. These conditions had been achieved by the adoption of very fine powders and blowing through immersed tuyeres. Whether carried out in a converter or ladle, the desulphurisation operation was very simple; the liquid pig iron was poured into the vessel with the tuyeres remaining above bath level. During the pouring, the introduction of unwanted slags such as blast-furnace or mixer slags must be avoided as far as possible.

After a sample of the melt had been taken, nitrogen was admitted through the tuyeres and then lime and as soon as a white cloud appeared at the mouth, the tuyeres were immersed by simply rotating the vessel for the duration of the operation which lasted only a few minutes. At the end of this period, the vessel was returned to its starting position with the tuyeres above the bath, and the supply of lime and nitrogen was cut off.

The process enabled rapid and efficient desulphurisation of the iron melt to be carried out, so that low residual sulphur contents of less than 0·010 per cent. could be obtained in a few minutes. The addition, to the lime, of a strong reducing agent, such as aluminium, facilitated the attainment of very low sulphur contents, of less than 0·004 per cent.

The discussion was opened by Mr. R. P. Towndrow who said that the perfection of a cheap single process which would enable steelmakers to desulphurise their liquid pig iron while still allowing considerable latitude to the blast furnaceman would be a valuable development. Many of the processes so far advocated, however, were intended for desulphurising pig iron in relatively small quantities, namely, up to from 20 to 30 tons. While this would serve for a Bessemer melting shop, an open-hearth plant would required the desulphurising process to be applicable to batches of from 100 to 200 tons. Such a development would mean that many problems would have to be overcome.

He would like to ask the authors whether, when compressed air was blown through the pig iron instead of nitrogen, any significant reduction in silicon occurred.

In reply, Mr. Trentini stated that experiments had been made on small quantities of liquid pig iron. Increasing quantities had been tested and melts of 15 tons and of up to 50 tons were envisaged. Compressed air did not lower the silicon percentage very markedly. Thus, in a recent test, while the sulphur had been brought down from 0·062 per cent. to 0·012 per cent. by compressed-air blowing, the silicon had decreased from 1·65 per cent. to 1·42 per cent. only. To remove silicon, oxidising conditions were necessary but to remove sulphur reducing conditions were needed. Thus the process described in the paper would not remove both silica and sulphur in the same ladle.

Dr. E. T. Turkdogan asked the authors whether they had tried using calcium carbide, instead of lime, and Sir Charles Goodeve asked them whether their lime contained sulphur at the end of the operation and whether lime dust was discharged into the melting-shop atmosphere.

Mr. Trentini, in answer, said that a little dust did appear above the ladle. Samples of this had been taken and it had been found to contain 2, 3 or even 4 per cent. of sulphur.

Mr. H. G. W. Debenham asked the authors whether the tuyeres were an essential part of the process or whether an ordinary lance could be used. He also asked what ladle lining was used. In answer, Mr. Trentini said they had used ladles having a basic lining but it had soon been found that the lining had no effect on the reaction, which was between the liquid metal and the lime. Hence, nowadays, ordinary firebricks were used for the lining. The adoption of tuyeres had greatly improved the results obtained. At the commencement lances had been used, but the tuyeres now utilised gave far better results.

Mr. D. P. G. Davis wondered whether there was any reasonable possibility that compressed air would be adopted in conjunction with multiple tuyeres which would be pushed down into the metal, thereby lowering the sulphur content from 0·09 to say 0·03.

In a final answer, Mr. Trentini stated that the process was still in a fluid state and that many more experiments would be needed before anything approaching finality could be attained.

In reply to Dr. Turkdogan regarding the use of calcium carbide, he said that the price of this chemical was far higher than that of lime, although, of course, it was very efficient.

Mr. R. Mather, from the chair, in a brief final comment, said that the present investigation had brought nearer the desulphurisation of "ordinary" steels, namely, the steels made regularly in millions of tons for many applications.

SULPHUR PARTITION

The first paper presented at session "D" was a contribution from the Chemistry Department of the British Iron and Steel Research Association, entitled "Sulphur Partition between Gas, Slag, and Metal Phases under Iron and Steelmaking Conditions." It was by Dr. E. T. Turkdogan, head of the physical-chemistry section of the Chemistry Department.

The author concluded that applying his calculations, based on the results of numerous laboratory experiments, to works' data, it appeared that the sulphur transfer to and from the slag and metal phases attained equilibrium under normal iron and steelmaking conditions.

The belief that the sluggishness of the carbon-oxygen reaction in iron was the cause of the apparently high residual sulphur in blast-furnace iron had been confirmed. Despite this, however, in blast-furnace practice the sulphur and manganese distributions between slag and metal attained equilibrium. This state of equilibrium could be changed by removing the excess dissolved oxygen in carbon-saturated iron either by allowing the carbon-oxygen reaction to proceed further or by adding a suitable deoxidiser, such as aluminium, silicon, or manganese. This was followed by the return of silicon and manganese to the metal and a lowering of the sulphur content of the iron.

EFFECTS OF THE IMPACT TEST

The last two papers presented at session "D" were considered jointly. The first was "A Study of Impact Tests and the Mechanism of Brittle Failure" by Professor C. Crussard, Mr. R. Borione, Mr. J. Plateau, Mr. Y. Morillon and Mr. F. H. Maratray, of the IRSID research staff. The authors stated that the object of their study was to clarify the fundamental

phenomena associated with impact tests. It had been observed that fracture could be initiated either at the surface (at the root of the notch) or internally. With decreasing temperature, the former mechanism gave way to the latter. The presence of permanent bending and of regions of plasticity showed that fracture was always preceded by plastic deformation, even in the case of brittle specimens where fracture was initiated internally. The role of this preliminary plastic deformation was evaluated by making complementary low-temperature tensile tests, which led to the conclusion that slight deformation caused internal stresses which embrittled the metal, while heavy deformation subsequently reduced this embrittlement. In impact tests, plastic deformation modified both the intrinsic brittleness of the metal and the distribution stresses, which could be used to explain the change from one mode of fracture to another.

The second paper was entitled "Some Effects of Heat Treatment and Microstructure on the Transition Temperature of a 0·24 per cent. Carbon Steel." It was by Mr. G. Burns and Mr. C. Judge and described work carried out at the Admiralty Materials Laboratory, Holton Heath, near Poole, Dorset. The authors stated that among the factors known to affect the temperature at which the fracture of mild steel in a notched-bend test changed from a tough to a brittle character was the thermal history of the material, particularly that part of the history which followed the conclusion of hot working.

Using a ½ in. thick plate of steel containing 0·24 per cent. of carbon and 0·55 per cent. of manganese, and assessing the transition temperature by the first appearance of cleavage fracture in a notched slow-bend test, the main factor affecting the transition temperature of this steel was the austenite grain size at the beginning of the final cooling; if it were coarse the steel would have a high transition temperature, if it were fine a low transition temperature could be attained by suitable cooling.

To cause the steel to show the lowest transition temperature which could be developed from the original austenite grain size, the cooling rate down to about 700 deg. C. should not be slower than the rate of cooling of a ½ in. thick plate in still air (about 70 deg. C. per minute), but there appeared to be no advantage in exceeding this rate. The cooling rate from 700 deg. to 600 deg. C. could, with advantage, be faster than the rate of a ½ in. plate in still air, and could usefully be as high as 200 deg. C. per minute. Below 600 deg. C., the rate of cooling appeared to have no significance, provided it was not so rapid as to lead to quench-ageing effects in the steel.

THE FRENCH IRON AND STEEL INDUSTRY

A paper entitled "The French Iron and Steel Industry" was not presented but had been specially prepared for the meeting by Mr. Marc Allard, director-general of IRSID. In the course of this, he stated that the iron and steel industry of France was based on the ore of Eastern France, with works in the Nancy and Longwy areas, and especially in the Moselle basin, around Metz. It benefited in this region from the important deposits of coking coal in Lorraine, which had been exploited only recently. In the west of France the Mondeville works were also situated on an ore field, near Caen. In the north of France, steelworks had been set up on the coal-mining region; they received their ore supplies from the east, from Normandy, and by sea from Africa. In central France steelmaking was carried out in the coalmining areas, in the region of Saint-Etienne and Le Creusot.

The overall production of steel in France for 1955 had been 12,600,000 metric tons. Of this total Eastern France was responsible for 66·2 per cent., Northern France for 22·2 per cent., Western France for 4·3 per cent., and Central and Southern France for 7·3 per cent. Basic Bessemer steel represented 61·7 per cent. of the total, open-hearth steel 31 per cent., and electric steel, 7·3 per cent.

ANGLE SECTIONS IN BENDING

DETERMINATION OF LIMITING DESIGN STRESS

By J. Jennings

When an angle is used as a beam, the plane of the applied bending moment being parallel to one of the legs, the calculation of the maximum stress by the methods usually adopted, using data supplied in section tables, is a tedious process. Under these conditions the material of the angle is unsymmetrically disposed about the plane of the bending moment, and therefore the equations used for symmetrical sections are not applicable. The method usually advocated is to resolve the bending moment into two components in the direction of the two principal axes of the section, apply the usual formula to each component in turn and then add the resulting stresses at the point judged to be the most highly stressed. Thus, considering Fig. 1, O U and O V are the major and minor principal axes, respectively, and P is found to be the most highly stressed point. The stress at P due to a bending moment in the OY-plane is

$$f_1 = \mathrm{M}_x \left(\frac{u_1 \sin \alpha}{\mathrm{I}_v} + \frac{v_1 \cos \alpha}{\mathrm{I}_u} \right). \quad (1)$$

Section tables generally give the value of I_u, I_v and α, but the values of u_1, and v_1 are left to be determined.

It occurred to the writer that a good approximation to the properties of an angle could be obtained by simplifying it to two lines of small thickness t situated along the centre-line of the legs. There is a certain amount of "give" and "take" about the approximation and it might be that the results were close enough for practical purposes.

The values of I_u, I_v, α, u_1, and v_1 are all complicated even on the basis of this simplification, so the alternative method of solution based on the product of inertia I_{xy} was used. The formula for stress at any point in a section is given by*

$$f = \frac{\mathrm{I}_y y - \mathrm{I}_{xy} x}{\mathrm{I}_x \mathrm{I}_y - \mathrm{I}_{xy}^2} \mathrm{M}. \quad . \quad . \quad (2)$$

For the simplified section shown in Fig. 2, the following formulae may easily be derived:

$$\text{Area} = (a + b)\, t \quad . \quad . \quad (3)$$

$$\bar{x} = \frac{b^2}{2\,(a + b)} \quad . \quad . \quad (4)$$

$$\bar{y} = \frac{a^2}{2\,(a + b)} \quad . \quad (5)$$

$$\mathrm{I}_x = \frac{a^3\, t\, (a + 4\, b)}{12\, (a + b)} \quad . \quad (6)$$

$$\mathrm{I}_y = \frac{b^3\, t\, (4\, a + b)}{12\, (a + b)} \quad . \quad (7)$$

$$\mathrm{I}_{xy} = \frac{a^2\, b^2\, t}{4\, (a + b)} \quad . \quad . \quad (8)$$

$$\mathrm{I}_x \mathrm{I}_y - \mathrm{I}_{xy}^2 = \frac{a^3\, b^3\, t^2}{36}\dagger. \quad . \quad . \quad (9)$$

It is to be noted that a and b are less than the length of the two legs of the angle by half the thickness.

The errors in the approximation are due to:

(*a*) A small overlapping square of side $\frac{1}{2}t$ which has been displaced inwards at the root of the angle.

(*b*) The omission of the effects of the spandrels formed by the root and toe radii.

(*c*) The omission of the quantity $\frac{1}{12} b\, t^3$ and $\frac{1}{12} a\, t^3$ in I_x and I_y, respectively.

Nevertheless, the positive and negative areas due to the spandrels practically balance, since the root radius is about $\sqrt{2}$ times the toe radius. The effects of (*a*) and (*b*) on $\bar{x}$ and $\bar{y}$, and of (*a*), (*b*) and (*c*) on I_x and I_y almost cancel one another, but for I_{xy} the effects of (*a*) and (*b*) are additive. The total error is, however, relatively small for normal angles.

With the origin at the centroid, the equation to the neutral axis is

$$y = \frac{\mathrm{I}_{xy}}{\mathrm{I}_y} x = \frac{3\, a^2\, x}{(4\, a + b)\, b}. \quad . \quad (10)$$

It is found that this line cuts the horizontal leg at a distance of $\frac{1}{4}b$ from the toe. Thus, if required, the neutral axis for an angle section with the bending moment parallel to one of the legs can be drawn in at sight. The maximum stress will occur at the greatest distance from the neutral axis. Examining the points A, B, and C, in Fig. 2, it will be found that

$$p_1 : p_2 : p_3 : : 2\, a^2 + a\, b : 2\, a^2 : a^2 \quad . \quad (11)$$

so that p_1 is always the greater distance. Thickness will affect the ratios somewhat but not sufficiently to alter the order of magnitude. Substituting $y = a - \bar{y}$, and $x = \bar{x}$ in equation (2) gives the following equation for the maximum stress:

$$f_1 = \frac{3\, (2\, a + b)}{a^2\, (a + b)\, t} \mathrm{M}. \quad . \quad (12)$$

This makes the section modulus, z, for point A

$$z = \frac{a^2\, (a + b)\, t}{3\, (2\, a + b)}. \quad . \quad (13)$$

Stresses for points B and C could be found approximately by using the ratios from equation (11).

A further approximation can be made in the equation for maximum stress by assuming that this occurs on the centre-line at the end of the leg; the error involved in this is small because of the toe radius.

For the 4 in. × 3 in. × ½ in. angle used as an example by Salmon* the following are comparable figures obtained by the suggested formulae, and by a more accurate estimation. For this section, $a = 3{\cdot}75$, $b = 2{\cdot}75$, $t = 0{\cdot}5$.

TABLE I. *Comparison of Approximate and Accurate Properties*

Quantity	Approximate formula	Accurate estimation	Difference, per cent.
Area, in.² ..	3·25	3·25	0
$C_x = \bar{y} + \frac{t}{2}$, in.	1·33	1·32	0·6
$C_y = \bar{x} + \frac{t}{2}$, in.	0·83	0·82	1·2
I_x, in.⁴	4·98	4·97	0·2
I_y, in.⁴	2·37	2·37	0
I_{xy}, in.⁴ ..	2·04	1·98	3·3
$\mathrm{I}_x \mathrm{I}_y - \mathrm{I}_{xy}^2$, in.⁸	7·63	7·85	− 2·8
z, in.³	1·485	1·438	3·3

The maximum stress is proportional to $\frac{1}{z}$ and therefore the approximate formula will give a value 3·3 per cent. low for this particular angle. As there is a rolling margin allowed on thickness of ± 2½ per cent. it would appear that the degree of accuracy obtained is very good indeed. As the accuracy depends on the relative thickness and radii and one would expect that a small angle section, such as 1 in. × 1 in. × ¼ in., might show a marked discrepancy. But as a matter of fact, a calculation such as that above shows an error of only 4·5 per cent. in the maximum stress.

If, as may be suspected, the angle is often treated as though it were a symmetrical beam, the errors are far greater than that due to the formulae given above. For example, taking the 4 in. × 3 in. × ½ in. angle, the value of z_x is given as 1·853 in.³ in the section tables. Using

* E. H. Salmon, D.Sc., *Materials* and *Structures*, vol. 1, page 168, and other sources.

† $\mathrm{I}_x \mathrm{I}_y - \mathrm{I}_{xy}^2$ is invariable for all pairs of perpendicular axes through the centroid and is equal to $\mathrm{I}_u \mathrm{I}_v$.

* loc. cit.

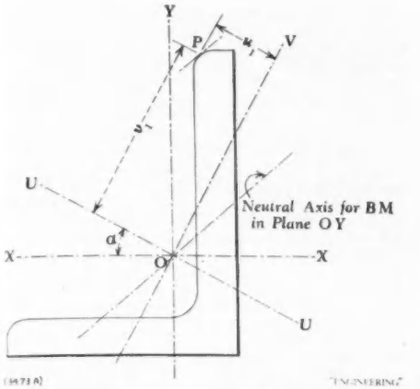

Fig. 1 Angle section, showing principal axes and the point, P, of maximum stress. Accurate calculation of this stress, based on section table data, is complicated ; if, for simplicity, the section is treated as a symmetrical beam the possible error is as much as 22 per cent.

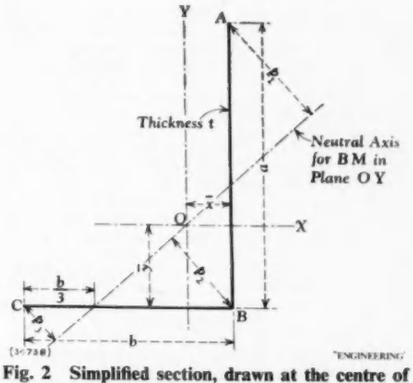

Fig. 2 Simplified section, drawn at the centre of the legs of the angle. Simple formulae make calculation of the maximum stress straightforward and sufficiently accurate for design purposes.

this value will underestimate the stress by 22½ per cent.; for the 1 in. by 1 in. by ¼ in. section, this error is 19 per cent.

Treating the angle as a thin section of uniform thickness the shear stress, q, is given by:

$$q = \frac{F}{I_x I_y - I_{xy}^2}\left\{I_y \int_0^s y\,ds - I_{xy}\int_0^s x\,ds\right\} \quad . \quad . \quad (14)$$

where s is the distance of a point from one end of the section, and F is the shear force due to loading perpendicular to the axis of x. The maximum shear stress occurs in the vertical leg on the neutral axis, and is given approximately by the following formula:

$$q_{max.} = \frac{3}{2}\frac{F}{a\,t}\frac{(2\,a+b)^2}{(a+b)(4\,a+b)} \quad . \quad (15)$$

This has a maximum value of $\frac{4}{3}\frac{F}{a\,t}$ when $b = 2a$, and tends to a minimum value of $\frac{3}{2}\frac{F}{a\,t}$ at $b = 0$.

There will be no torsion on the section provided the loading is applied in the plane of the vertical leg, since the shear centre is at the junction of the centre-lines of the two legs. If the load acts at a distance from this leg the maximum torsional shear stress is given by:*

$$q_t = \frac{3\,T}{(a+b)\,t^2} \quad . \quad . \quad (16)$$

where T is the torsional moment. This shear stress is practically constant over the long edges of both legs of the angle, so that the maximum shear stress will occur on the neutral axis and will be the sum of the values of $q_{max.}$ and q_t calculated from equations (15) and (16). In conclusion, it will be seen that the maximum bending and shear stresses can be worked out accurately to within a few per cent. of the true values using only the centre-line lengths and angle thickness.

* S. Timoshenko & A. Goodier, *Theory of Elasticity*, 2nd edition, page 287.

Institution of Naval Architects Spring Meeting (*concluded from page* 530)

VIBRATION AND CORROSION IN SHIPS

The concluding technical session of the Spring Meeting of the Institution of Naval Architects, held in the Weir Hall at their headquarters at 10 Upper Belgrave-street, London, S.W.1, on March 22, was divided into two parts, the second of which was a joint meeting with the Institute of Marine Engineers. The first part of the session, during which the chair was taken by Dr. R. W. L. Gawn, C.B.E. (vice President), was devoted to the presentation and discussion of a paper by Mr. J. W. Ramsay, B.Sc. (Eng.), of the Royal Naval Scientific Service, entitled "Aspects of Ship Vibration Induced by Twin Propellers."

VIBRATION INDUCED BY TWIN PROPELLERS

Mr. Ramsay explained that the need to reduce or, if possible, avoid vibration in warships had become more important with the introduction of radar and gunnery control equipment of growing complexity and a high order of sensitivity. In general, the vibration of a ship's hull depended upon the nature and magnitude of the periodic forces impressed upon it, and the sympathy accorded to those forces by the elastic properties of the hull structure. In turbine-driven ships, in which out-of-balance forces in the main machinery were negligible, the periodic forces causing vibration arose solely from interaction between the propellers and the hull or its appendages. Excitation could arise from hull pressure forces, due to the fluctuating pressure field round the propellers; mixed wake forces, acting on the propeller blades and accompanied by reaction forces at the boss; hydrodynamic unbalance forces, due to dissimilar distribution of thrust and torque between the individual blades of a propeller; and mechanical unbalance forces, which might occur if the propeller is not statically balanced or if the shaft was not in alignment. In the investigation described in the paper, a vibration generator mounted on the upper deck of a destroyer was used to ascertain the elastic response of the hull to a known harmonic shaking force, as a check on the accuracy of the theory relating to natural frequencies and their significance. The Losenhausen generator used was rated to develop ±2 tons at 510 cycles per minute, and other forces in proportion to the square of the frequency. It was considered that the elastic response of the hull girder conformed to the analytical principles on which most methods of natural frequency are based, and that the first five or six natural frequencies of vertical flexural vibration could be calculated as accurately as the estimates of hull strength and entrained water allowed. Above the frequency of the six-node or seven-node vertical mode of vibration, further resonance of the hull was unlikely. Vibration was only significant at the stern and, in the absence of local flexibilities, would remain approximately constant at all ship speeds.

Professor S. J. Palmer, O.B.E., opening the discussion, said that Mr. Ramsay had rightly pointed out that vibrations in warships were becoming more troublesome; not because there had been any marked increase in the way the ships were vibrating, but because they were carrying more sensitive equipment, such as radar aerials, which were not able to withstand such variations. It was not uncommon to find that some of these aerials were shaken off when the vibration was at its worst, as when turning at high speed. What could the ship designer do to reduce those vibrations ? The naval architect always tried to shape the ship's lines so that the flow past the propeller was as uniform as possible, and he kept a minimum clearance between the propeller and the hull, based on experience. In Admiralty practice, the clearance was usually 20 per cent. of the propeller diameter. The reduction in propulsive efficiency with smaller propeller diameters limited the amount of clearance that could be allowed; but the form of the ship, the diameter of the propeller and also the r.p.m. of the shaft had to be decided long before the structural design of the hull could be completed, so that, by the time the natural frequencies of the hull could be calculated, the only relevant variable still to be settled was the number of blades. Accurate methods for forecasting the natural frequencies led to a better understanding of the mechanism of hull vibration, but would Mr. Ramsay agree that, in practice, the calculation of those values for a new design could be used only to decide the number of blades ?

Mr. J. L. Kent, C.B.E., referring to merchant ships with twin or single propellers, pointed out that, when the waves passing over the propeller were short in length but fairly steep, the crest as it passed over the top of the propeller caused the thrust and the torque to drop, and as the trough passed over, the thrust and the torque rose. With larger waves and twin-screw vessels, as a propeller came towards the surface the thrust went up and, in many ships he knew, vibration started; as the propeller went down, the vibration stopped.

A CASE FOR MANY BLADES ?

Mr. L. G. Stevens said that the author appeared to have established a clear case for working with as many blades as possible. By using an infinite number of infinitely thin blades, it might be thought, vibration could be dispensed with altogether; but, of course, practical blades were not infinitely thin, and there must be a limit to the number of blades which could be used beneficially. Would the author regard five blades as being about the optimum from that point of view, or would six or seven be better ? He thought that the first urge to vary the number of blades in order to reduce vibration did not come from the vibration of the hull, but was suggested rather by the need to do something about resonant vibrations in the shafting, gearing and propeller in combination; and it seemed that the best solution of the hull vibration problem might not necessarily be the best from the machinery aspect. He invited the author's comments on that aspect.

From the diagrams in the paper showing calculated variation in harmonic pressure with tip clearance, there was with increasing clearance up to 20 per cent. reduction of pressure on the hull. The pressure induced by a three-bladed propeller was about three times that induced by the five-bladed propeller at 20 per cent. clearance; alternatively, it was possible to work to about half the clearance and induce the same pressure with five blades as with three. The author had plotted his results in the form of hull clearance as a percentage of the diameter of the propeller. Did he regard that as a good general criterion, or not ? There had been many suggestions that other factors ought to be included in determining hull clearance, one of them being the length of the ship as it affected the thickness of the boundary layer. The rather surprisingly small effect of the boundary layer might have something to do with that.

Wide blades were regarded as having a number of beneficial effects, but the possibility of adopting them was seriously limited, not only by reason of problems concerning manufacture, fitting and maintenance, but also by the associated drop in propeller efficiency. In general, merchant-ship propeller blades were narrower than those in warships. Would the author suggest that merchant ships were more likely to suffer vibration than warships ?

Mr. A. Silverleaf thought that, while the paper did not give all the answers, it did give a lot more than any other paper had done on that aspect of ship vibration. He was particularly concerned to know what would be the slope of the curves showing the calculated variation in harmonic pressure with tip clearance. It was the slope, rather than the relative values, that mattered, because it gave a clear indication of whether there was any significant advantage to be achieved by increasing the blade-tip clearance from, say, 0·2 to 0·25 of the diameter. Graphs in the paper showed what could be got in that way. He noticed that the residual amplitude at the higher frequencies, up to 500 to 750 cycles per minute, were much less at the bows than at the stern, which he would ascribe to the attenuation of the higher modes along the length of the ship. It was a phenomenon which frequently occurred. The author had noticed no depth-of-water effect, and he seemed a little surprised; but with a depth of water of 30 to 40 ft., and a draught of 10 to 12 ft., Mr. Silverleaf said that he would not expect significant differences, though he doubted whether depth-of-water effect was solely a depth/draught factor.

Mr. P. W. Ayling said, with regard to the theoretical prediction of hull criticals, that in merchant ships that was considered to be of more than academic interest, particularly as attention must be given to horizontal and torsional modes as well as vertical

vibration. Did the author consider that the experimental results were affected by the fact that the vessel was berthed alongside a quay, and had he any further comments on the similarity of the results at high and low water? According to published evidence, frequencies for vertical vibration might be affected when the depth of water was less than five times the draught.

Mr. S. G. Lankester said that the author had mentioned the possibility of the local wake of shaft bracket arms or bossings giving rise to large forces, mainly in the transverse direction. In Admiralty designs, particular care was taken, including using model experiments, to ensure the best possible alignment of shaft brackets and thereby to reduce local wakes to a minimum. In a ship fitted with bossings, as opposed to "A" brackets, there was a rather increased danger of a local wake. A wake survey, mentioned in a paper by Dr. F. H. Todd to the British Association in 1938, showed quite a considerable wake "shadow" in the way of the bossing, at an angle in excess of 45 deg. to the vertical, so that there would have been a vertical reaction nearly as large as the horizontal component. Experience had shown that ship vibration could be minimised not only by paying attention to adequate hull clearance, but also by propeller blade form and gradual wake penetration. One of the author's graphs suggested that, at 20 per cent. tip clearance, the vibration might be reduced at source in the ratio of 3 : 10 by increasing the number of blades from three to five. Since the frequency was increased, and since acceleration (which might be the most important criterion) was proportional to the square of the frequency, the reduction in acceleration, if only 75 : 90, was not significant.

Mr. Ramsay, replying to the discussion, noted that Professor Palmer had asked what use the prediction of natural frequency was when the ship was already designed structurally and required only a propeller to be fitted to enable it to go to sea. To answer that question properly, he must distinguish between merchant ships, which operated at a low speed, and Royal Navy ships. When the revolutions at maximum r.p.m. induced forces at a comparatively low frequency, resonance of the hull must be avoided at all costs. So far as Admiralty ships were concerned, he agreed with Professor Palmer that the value of prediction was somewhat doubtful; mainly because they were not then concerned with resonance, being too high in the frequency range for it to happen anyway, and, secondly, because they were more concerned to keep down the forces themselves and the general level of vibration. As to Mr. Stevens's point, the ultimate aim was not to induce propeller designers to have as many blades as possible. The President had said at the annual dinner of the Institution that the ideal design was likely to be an ideal compromise, but before the designer could arrive at the ideal compromise he must have as many facts as possible at his disposal. Mr. Stevens had also asked if he had considered the effect of the number of blades on shaft vibration. He had considered only the effect on hull vibration. Then Mr. Stevens made the point that larger blade areas, while probably tending to reduce vibration, were likely to meet with with opposition because they resulted in the use of too much fuel. On that point, he quoted the Duke of Edinburgh, who had said recently that "what the Merchant Navy do with minimum costs, the Royal Navy do regardless."

Mr. Ramsay added that he would reply further in writing.

CORROSION OF CARGO SHIPS

For the second part of the final technical session of the 1956 Spring Meeting, on the afternoon of March 22, when the members of the Institution of Naval Architects were joined by the chairman of the Institute of Marine Engineers (Mr. Pemberton) and a number of members of the Institute, the chair was taken by Sir Stanley V. Goodall, K.C.B., O.B.E., who welcomed the visitors and invited Mr. Pemberton to join him on the platform. The paper, presented by Mr. H. J. Adams, M.Sc., Principal Surveyor for Ship Research, Lloyd's Register of Shipping, and Dr. J. C. Hudson, head of the Corrosion Laboratory of the British Iron and Steel Research Association, dealt with "The Corrosion of Cargo Ships and Its Prevention."

After an introductory discussion of the general problem, reviewing the occurrence of corrosion in ships, the effect of steel quality and of design, and the question whether welding affected the liability to corrosion, detailed consideration was given to the corrosion of underwater plating, corrosion of the superstructure, and internal corrosion. In an appendix, extracts were given from the Rules of Lloyd's Register relating to corrosion, and a second appendix described four serious cases of corrosion reported by Lloyd's surveyors. A large part of the paper was devoted to methods of protecting the surfaces of a ship's structure and of maintaining that protection. The tests indicated that the use of welding introduced no appreciable corrosion hazard.

The discussion was opened by Dr. S. Livingston Smith, C.B.E., who referred to the authors' point that paint removal was one of the commonest reasons for corrosion. In this, the turbulence of the water doubtless played an important part, especially at the sternpost and rudder in single-screw ships. The probable action was that a "hydraulic blast" from the screw tore off the protective coating of paint, galvanic action set up between the bronze propeller and the bare steel, and the steel corroded. Next, the scouring action of the race washed away the corrosion products and supplied more oxygen, and the result was a most efficient corrosion mechanism. It seemed that paints could not stand up well to the scouring action of the water. Could the authors suggest any other protective coating which would be more adherent? Would a sprayed metal coating be better and, if so, what metal would they suggest? Alternatively, would cathodic protection provide the answer?

Apparently the incidence of corrosion on the stern frames and rudders of single-screw ships was greater now than it used to be. That was probably due to two causes: first, the tendency to put more power on to a single shaft, producing more "hydraulic blast," and, secondly, the increase of shaft r.p.m., especially with the change from steam to Diesel propulsion.

Mr. J. Barrington Stiles was disappointed that the corrosion of oil tankers was excluded from the paper, because that was one of the worst and most urgent problems. Under the heading of surface preparation of superstructures, it was rightly said that maximum paint durability was secured by putting the first coat on to a clean steel surface, free from millscale and rust, and that the best way to secure that was by pickling or grit-blasting. That, however, applied only to protective systems which were exclusively paint; where it was economically practical, grit-blasting and metal spraying provided a base which would substantially improve the durability of a subsequent appropriate paint treatment. Apart from the virtues of zinc and aluminium in protecting steel mechanically and sacrificially, those metals, when sprayed, provided an ideal base for paint; the paint was mechanically locked to the surface.

The authors had said that, while metallic coatings were a valuable additional defence against corrosion, it was improbable that extensive use would be made of protective metallic coatings for the hulls of merchant ships. On what did they base that opinion? Hitherto these coatings had been chiefly confined to barges, fishing vessels and yachts, but he expected to see larger vessels tackled in the very near future. The protection of steel-hulled yachts emphasised the appearance factor, in which the substantially lower cost of maintaining a spotless condition could offset the initial extra. The position of cargo vessels fell somewhere between the two. Using $\frac{3}{16}$ in. zinc wire, a coating of 0·010 in. thick could be applied to a hull at upwards of 1,000 sq. ft. per 9-hour day. The authors appeared to be so much in favour of brush painting that they had scarcely been fair to spray painting. For the matt condition of grit-blasted or metal-sprayed surfaces, it was best to spray the paint; brushing was satisfactory, but rolling was an extremely doubtful method.

Mr. J. M. Murray, M.B.E., said that the evidence put forward on the wastage of old and new ships was very interesting, but he doubted whether it was relevant to ships being built at the present time. During the 30 years to 1930, there were few changes in the methods of steel production; it was after 1930 that the fast rolling mill was introduced, and, with it, a different type of millscale. A great majority of cases of corrosion of outer shell plating could be attributed to the imperfect removal of millscale. He was pleased that the authors had not even mentioned an explanation which was often put forward, but which had no foundation, that of stray electric currents from the ship's generators.

Some years ago, he had inspected the Queen Mary in dry dock and was much impressed by the underwater surface. The state of preservation of the steel was excellent, and the edges of the seams and butts were unusually sharp for a ship of her age. No doubt the very complete weathering process to which the ship was subjected during construction was in some degree responsible for the excellent condition of the bottom.

He was under the impression that the main advantage of applying paint by brushing was that any small beads of moisture on the surface of the steel were worked through the composition to the surface, where they evaporated, whereas when rolling or spraying was used the moisture was entrapped under the surface of the paint.

Mr. S. J. Jones noted, in connection with air conditioning, that "relative humidity" appeared to be used as a basis concerned with the possibility of rusting. Relative humidity was the ratio of the vapour pressure of the air in being to the vapour pressure of saturated air at the same temperature. In other words, "relative humidity" meant little until it was related to air temperature. It might be assumed, from the reference attributed to W. H. Vernon, that, if the surrounding air was at a relative humidity below 60 per cent., little or no damage could result to steel; but there were many cases in ships' voyages where such conditions could occur and where damage to cargoes and ship structures could result, even though the surrounding air relative humidity was below 60 per cent. There was, in fact, a rule which could be applied to ships' holds. It was that, when the outside air dewpoint was below the inside air dewpoint, maximum ventilation should apply; and where the inside dewpoint was less than the outside air dewpoint, air recirculation or closure should be applied. If dehumidifying plant were fitted, it enabled the dewpoint of the air inside the holds to be kept down. Another source of condensation in holds which could cause trouble, even though the precautions mentioned had been taken, was due to the proximity of refrigerated spaces. That trouble had been overcome successfully on a number of ships recently by the use of "thermal injection," which was the application of low-voltage electric heating.

GOOD SURFACES NEEDED

Mr. G. A. Bassett, C.B., said that there was no doubt that the preparation of surfaces was all-important, whether sandblasting or cleaning was used; to use a quick method was asking for trouble. If sandblasting could be introduced into the shipyards; in the conditions obtaining in this country, it was the best method. There was a difference of opinion as to whether, after sandblasting a ship, the inhibitor coating should be put on at once or after a month or so. When the Queen Mary and Queen Elizabeth were descaled to the water line —involving some 15,000 square yards—an inhibitor coating was put on as a base, and the descaled area was never left uncovered overnight. Undoubtedly, the result on the Queen Mary was first class.

Mr. J. A. Shepherd said that the development of the protection of hulls by zinc spraying had been retarded only by difficulties associated with shot-blasting and the high cost of zinc over the war years, plus reluctance on the part of shipowners to "experiment" with a process not already established; but sufficient evidence was now available to show that the application of a layer of zinc on to the suitably prepared hull of a vessel, subject to either fresh or salt water, would provide protection out of all proportion to its initial cost.

Mr. L. G. Stevens said that, generally, Admiralty practice conformed to the procedures recommended in the paper. He emphasised the need for careful surface preparation and the application of paint in good weather conditions. A great deal of effort had been and was being devoted to the improvement of paints, but much of that effort would be wasted if that counsel was not heeded. It was stated in the paper that the Admiralty normally hot-galvanised ship plate of $\frac{1}{4}$ in. thickness or less. That was not strictly correct. The fabrication of structures in galvanised plating presented a number of difficult problems, and one was that the areas where protection was most needed after welding were those where the zinc no longer existed. The authors pointed out, quite rightly, that, so far as the outside of the ship was concerned, the coating elsewhere would tend to protect the bare steel areas cathodically; but much of the corrosion occurred inside "dry" compartments—not so dry as they were thought to be—and there could be liquid contact between the unprotected areas and those galvanised. Would the authors prefer to treat such areas with zinc-rich paint or would they recommend metallising?

Mr. C. V. Manley said that the problem of corrosion was age-long; it existed with iron ships, though not to the same extent, and it was discussed in a paper presented to the Institution by Mr. Robert Mallet in 1872. One of the remedial measures advocated in those days was the copper sheathing of iron hulls, but apparently it was not proceeded with, for it presented strong defects regarding the method of attachment of the copper. One protective coating which apparently was found to be effective was that of long-boiled coal tar, [illegible] on when the iron was hot. It was striking [illegible] by way of practical suggestion, the present [illegible]ors repeated the advice given by Lloyd's Re[illegible] in 1888, when steel ships first began to be built.

When the Queen Mary was built she lay [illegible] the stocks for some years. It was said then [illegible] that would prove beneficial from the point of [illegible] of

corrosion, as it would result in a complete descaling of the structure by prolonged weathering. The authors gave some comparative results of annual inspections of the shell plating of the Queen Mary and Queen Elizabeth since 1949. Had they any similar information prior to 1949 which would show whether, as a result of the unusually long period of weathering mentioned, the plating of the Queen Mary did, in fact, show greater resistance to corrosion in service ?

Professor E. V. Telfer objected to the authors' use of the word " holidays " in paint, " a perfectly stupid terminology." He had looked up the *Oxford English Dictionary* and found that it dated from 1785; the definition was " A small gap in a tarred surface of a ship, generally not exceeding a quarter of an inch," so that nautical people were responsible for that perfectly hopeless word. His next terminological quarrel concerned the use of the word " turbulence," in a completely erroneous manner, for turbulence did not produce corrosion or erosion. The whole ship was working in turbulent water, and the greater part of every ship, provided it was looked after, was free from corrosion and erosion. What the authors really meant was that, if eddying flow or flow consisting of vortices impinged on various parts of the structure, there would be excessive corrosion. Vortices caused excessive aeration of the water, and there was a very high concentration of oxygen release.

Captain J. P. Thomson, O.B.E., confirmed the authors' remark that salt water in spray was a most destructive element from the corrosion point of view. He had tried many different manufacturers for paint and found that no paint made to-day would stand up on oil tankers. Some companies used acid-free tar. His company had had a ship for 15 years and sold her to a whaling company; she was now 42 years old. She went to the Antarctic every year as a whale factory ship and carried whale oil, lubricating oil and fuel oil. The wastage of shell plating was very small indeed.

Mr. J. H. K. Tait supported the authors' views on cathodic protection. He had been concerned with the protection during fitting-out of about a score of ships and did not think that any which had been protected cathodically during fitting-out had shown any pitting or corrosion of the steel when docked and examined. There was a suggestion that the provision of cathodic protection apparatus might impair the efficient working of a ship. He did not think that any master or chief engineer on any cathodically-protected ship in service even knew that he had the equipment fitted. The problem of the protection of oil tankers was one of reducing urgency. There were about 130 oil tankers so protected to date and others were being provided with protection at an increasing rate. He thought the time would come when the corrosion of oil tankers would be largely of academic interest.

Mr. H. T. Shirley thought that the authors seemed to dismiss the stainless steels rather summarily from the marine sphere. Obviously, no one would ever think of producing a whole hull of stainless steel; neither its availability nor its cost would permit that. But in connection with propeller shafts, propellers, etc., such materials had behaved very satisfactorily.

CORROSION FATIGUE

Mr. W. A. D. Forbes pointed out that the paper had not dealt with corrosion fatigue. In the past few years, the Admiralty Corrosion Committee had had to consider a number of instances of corrosion fatigue of outer bottom plating. It was a form of corrosion which might be more prevalent than was generally recognised, and it could be very dangerous. In outer bottom plating, it usually started in the characteristic form of a multiplicity of hairline cracks, which rapidly deepened and weakened the plating. In one instance, a piece of plating subjected to panting actually fell out during a voyage. Panting was one of the most likely causes of corrosion fatigue. The plating of merchant ships was less liable, perhaps, to this type of failure than that of warships, since it was generally thicker than in warships of corresponding size, and the frame spacing was less; but merchant ships were more liable to that trouble with the propelling machinery, shafts and rudders, as they spent a much greater portion of their lives under full power than did warships. If serious trouble, such as fracture, should arise with such items, the possibility that it might be due to corrosion fatigue should not be overlooked, because, in such circumstances, fracture could occur at well below the normal safe working stress.

Mr. Adams, replying to part of the discussion, noted Dr. Livingston Smith's point about corrosion around the stern post and rudder, of the type shown in the paper. Professor Telfer had objected to the use of the word " turbulence," but, whether or not it was strictly correct, he proposed to use that word and agreed entirely with Dr. Livingston Smith that it was the turbulence of the water in such positions which removed the paint and enabled corrosion to occur. At least one shipping company coated the stern post and the stern of their ships, for some distance from the propeller, with a very zinc-rich paint. In survey work, he had seen remarkable resistance to corrosion in internal parts of ships (which normally corroded heavily) when Bitumastic had been applied hot. He did not know whether the application of hot Bitumastic had been tried in the region round the propeller and the stern frame.

Mr. Barrington Stiles and Mr. Shepherd had brought forward a plea for metal spraying. The authors' experience of it was not large, but from that experience it appeared to be satisfactory. If metal spraying showed itself to be efficient and economic, it would not be long before shipowners started to use it, and its use would advance very rapidly. Mr. Murray had mentioned the difficulty of deciding whether modern steel was any worse or better than the steel of 30 years ago, and said it would be necessary to wait 20 years to find out. Mr. Adams thought that, 30 years ago, marine superintendents were probably saying that steel then was not so good as it was 30 years before.

With regard to surface preparation, Mr. Bassett's proposal to descale a certain number of plates in rotation was an excellent idea. A point which came out of Mr. Manley's remarks was that long-boiled coal tar, laid on while the iron was hot, was recommended round about 1870. That might have some connection with, or similarity to, the use of hot Bitumastic. Practically every speaker had emphasised the importance of good surface preparation and good painting conditions, with which everyone would agree. He would reiterate the importance of making provision for access. This was a matter of design, and unless difficult parts of ships were arranged so that they can be got at for painting, there would be corrosion in those places.

Dr. Hudson said that Dr. Livingtson Smith had asked what could be done to protect such parts of ships as the stern frames. He thought some of the present materials would stand up to the conditions; for instance, Neoprene, which had given very good results in similar applications. The cost might be prohibitive, however. It was generally agreed, both by the more theoretical people and the practical engineers, that in painting a steel structure, particularly under inclement conditions, brush application was very much the better.

UNIVERSAL IMPACT TESTING MACHINE

IZOD, CHARPY, OR IMPACT-TENSION TESTS

The use of the Izod machine for impact testing has long been standard practice in this country, the Charpy machine being used on a smaller scale. Recently, however, the need has arisen for impact tests at elevated and sub-zero temperatures, and for this purpose the Charpy machine is more convenient, as the specimen does not have to be clamped, and it can be placed in position quickly without significant change of temperature. As a consequence, it may often be necessary to provide for tests of both types.

To meet this requirement in a single machine the universal impact tester shown in the accompanying illustration has been introduced by W. and T. Avery, Limited, Soho Foundry, Birmingham 40. It is suitable for carrying out standard Izod and Charpy tests by means of quickly-interchangeable specimen holders and a reversible striker on the pendulum, and it can also, by the addition of special equipment, be used for impact-tension testing. Extra equipment can also be supplied for carrying out non-standard Izod and Charpy tests.

The Avery universal impact testing machine will carry out standard Izod or Charpy tests, and can be adapted for non-standard tests of these types and for impact-tension tests.

The machine has a cast iron base and pillar, on which is mounted, in anti-friction bearings, the striker pendulum. This has two starting positions, one for Izod tests at a striking velocity of 12·5 ft. per second, and the other for Charpy tests at 5 metres per second. The pendulum is supported in its starting position by a self-resetting toggle latch, controlled by a hand-lever on the left-hand side of the machine base. Accidental operation of the pendulum release is prevented by the fact that the hand-lever is spring loaded and can only be operated by a deliberate movement. There is also a stop for supporting the pendulum when grips are being changed; the illustration shows the pendulum at rest on this stop. The energy absorbed by the specimen is shown by a pointer traversing a circular chart 13 in. diameter, with two sets of graduations, 120 ft. lb. by 2 ft. lb. for Izod tests, and 30 kg. m. by 0·2 kg. m. for Charpy tests.

SIMPLE CHANGE-OVER

For Izod tests the specimen is clamped in a vice, which has removable gripping jaws to suit the specimen. A setting gauge, which locates in the V-notch in the specimen, enables it to be correctly located, and the grips are then closed by a wedge operated by a hand-lever on the right of the machine base. After a test, the grips are released, and any broken specimen which falls through them is delivered to the front of the machine by a built-in chute.

To change the machine over to Charpy tests the gripping jaws are removed, and an anvil block is fitted in their place. This supports the Charpy test piece, which is of the beam type, with the notch in the middle; no clamping is necessary in this case. A different type of striker is also needed for Charpy testing, and the striker in the pendulum is made with two striking edges, one for Izod and one for Charpy tests. By slackening a locknut the striker can be turned through 180 deg. to bring either face into use as required.

Impact-tension tests are carried out with a special block fitted in place of the normal striker in the pendulum. This block holds the specimen, which is made with screwed ends. The pendulum is allowed to fall in the usual manner, and as the specimen-carrier reaches the Charpy test anvil block one part of it makes contact with this block, thus imposing an impact-tension load on the specimen.

Fig. 1 The coach is winched into position so that the wheels to be machined rest on the drive rollers. The weight supplies the necessary adhesion and steady rollers are adjustable for wheels between 28 and 36 in. in diameter.

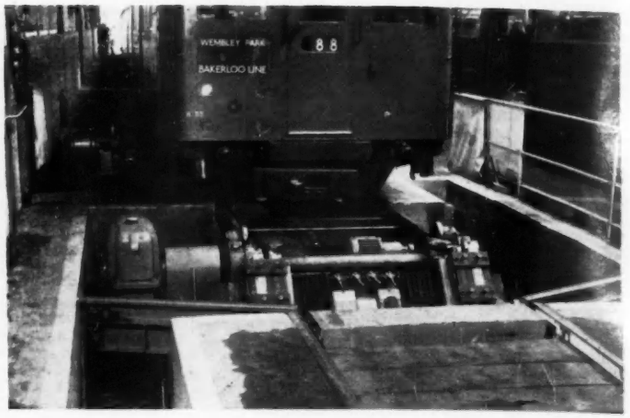

Fig. 2 When the wheels are on the rollers, the approach rails are swung clear and the tool holders moved outwards and upwards to contact the wheels. (For clarity the car is not in the correct position.)

MACHINING WORN WHEELS

PROFILES RESTORED WITHOUT REMOVAL FROM VEHICLE

Considerable savings in maintenance costs and time out of service are now being achieved by London Transport by the use of a new lathe which permits the machining of train wheels *in situ*.

It has been found that on rolling stock fitted with non-metallic brake blocks or inserts, wheel wear is generally confined to the treads, the flanges being relatively unaffected. This type of wear is equivalent to a deepening of the flanges, and restoration of the correct profile is a lighter machining operation than in cases where heavy flange wear has occurred. The new lathe performs this operation without the need for first removing the defective wheels, as has been the normal practice, or even for uncoupling the car in question from the remainder of the train.

In 1947 an experimental ground wheel lathe was installed at Golders Green Depot and gave encouraging results. Experience gained with it was used to develop the design of the new, and improved, machine. This machine, supplied by the Scottish Machine Tool Corporation, is now in regular use at London Transport's Neasden Depot. Fig. 1 shows the lathe with the car about to be drawn into position.

The lathe is situated below rail level on one of the inspection roads, in such a position as to accommodate a four-car unit on either side of it. Once the four-car unit has been shunted on to the appropriate road, it is finally positioned on the wheel lathe driving rollers by the operator, using a pneumatic cable winch.

The main shaft carrying the driving rollers is mounted in roller bearings and driven by a constant-speed 20 h.p. motor through a variable V-belt drive and worm reduction unit. Adhesion between wheels and driving rollers due to car axle loading is sufficient to transmit the cutting torque without slip.

Retractable steady rollers, situated at the rear of the machine, locate the wheels during machining; these are hydraulically operated and can be independently adjusted for wheel diameters varying between 28 in. and 36 in. Two thrust rollers, also hydraulically applied, secure the wheels laterally.

After the wheels have been located on the driving rollers, two hinged approach rails are swung clear to allow the tool holders to be moved outwards and upwards to their operative positions. This is the condition illustrated in Fig. 2, but for clarity the car is not in position on the machine. Quick power traverse is provided for the longitudinal and transverse movement of each tool slide independently by means of hydraulic clutches, the controls of which are conveniently grouped for the operator. Hand feeding is employed during cutting.

Two types of tool are used during the machining process: one is a roughing tool for topping the flange and the second is a profiling tool, of the plate type, for restoring the chamfer to the outer edge of the tread and reforming the flange profile. Each tool post carries one tool of each type so that both operations can be performed merely by traversing the tool slide. Tool holders are designed to minimise the overhang between tool and slide, thereby reducing tendency to chatter. Cutting speeds are infinitely variable between 13 and 34 ft. per minute and may be changed while the machine is in motion by altering the variable drive ratio.

Hydraulic power for clutches and rollers is supplied from an electrically driven pump which is interlocked with the main drive motor to ensure that power is available before the machine is started.

Electric control gear, supplied by the Igranic Electric Company, is contained in a pillar starter unit in the machine pit; it embodies a main isolating switch and automatic starting and overload equipment for the main motor, quick-traverse motor and pump motor. All motors are remotely controlled from a push button panel mounted on the front of the lathe, adjacent to the clutch controls.

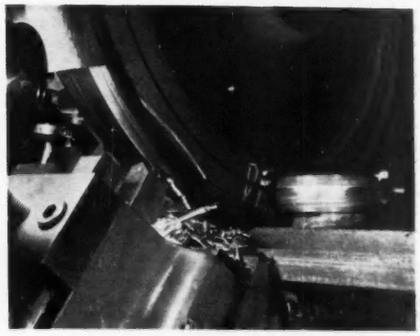

Fig. 3 The wheels are steadied by hydraulically operated rollers while the cuts are being made.

A modified double-headed high speed grinding machine has been installed in the machine shop for regrinding the right and left handed H.S.S. plate-type form tools. The grinding wheels are shaped to the tool profile and special rests are provided to ensure correct positioning of the tools during grinding.

It has been found desirable to regrind tools after turning approximately ten tyres.

AIRCRAFT AND GUIDED WEAPONS RESEARCH CENTRE

Armstrong Whitworth Expands

Sir W. G. Armstrong Whitworth (Aircraft) Limited, Coventry, a member of the Hawker Siddeley Group, has embarked on an extensive expansion and development programme for a fully-equipped aircraft and guided missile research and design centre on the site of their plant at Whitley, near Coventry.

The programme, which will cost £1 million, involves rebuilding the major part of the existing Whitley factories. The centre will include design offices, laboratories and experimental shops. Additional electronic computors, both digital and analogue types, and pressure-chamber facilities for testing materials under extreme climatic conditions, ranging from Arctic cold to sub-tropical heat, are to be provided, as well as a new mechanical test laboratory with twice the space and equipment of the existing facility at Baginton, the company's main plant. The company's Mach 3 wind tunnel, opened last year, is already established at Whitley, together with transonic and low speed tunnels.

The whole of the firm's design staff now at Baginton will move into the new centre. Additional staff will also be recruited. To meet the expansion of the design staff required, the company has also opened a branch design office in Birmingham. By the end of the year, the design office staff will have increased 100 per cent. over its strength at the middle of 1955. Some of the workshops connected with guided missiles, at present established at Whitley, will eventually be re-sited.

In parallel, there is to be a large-scale development at the company's test airfield at Bitteswell, Leicestershire. Runways are to be re-laid and strengthened and full night-landing facilities are to be installed. To combat noise during engine testing and aircraft run-up periods, sound-suppression pens will be brought into operation in the near future.

The new centre will be one of the largest concentrations of aircraft and missile research and design facilities in Great Britain.

Book Reviews

DESIGNING FOR REPETITIVE LOADING

Fatigue of Metals and Structures. By H. J. GROVER, S. A. GORDON and L. R. JACKSON. Prepared for the Bureau of Aeronautics, Department of the Navy, by Battelle Memorial Institute. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (2.50 dols.)

The desirability of making adequate provision against the possibility of failure by fatigue in the design of machines and structures subjected to varying loads has long been realised, and in recent years has become a prime necessity, particularly in relation to the design of aircraft structures. To assist in making this a practical possibility, the Bureau of Aeronautics, Department of the U.S. Navy, in 1941 sponsored the preparation of a book entitled *Prevention of the Failure of Metals under Repeated Stress* which summarised a great deal of the information then available concerning the fatigue properties of metals. *Fatigue of Metals and Structures*, also prepared for this Department by the staff of the Battelle Memorial Institute in 1954, represents an attempt to bring this service up to date.

The ultimate basis of design for any given service life is the curve, obtained from a fatigue test of a material, which relates the applied cyclic stress with the number of cycles of stress endured before failure occurs. Elemental data of this kind are supplied by the authors in 23 tables of fatigue strength of classified materials. These contain, in condensed form, the results of more than 1,700 separate fatigue determinations, not only at air temperature, but also including tests carried out at sub-atmospheric and elevated temperatures. In each case, the fatigue curve is "drawn" in tabular form by quoting the stresses endured for 10^4, 4×10^4, 10^5, 4×10^5, 10^6, 4×10^6, 10^7, 10^8 and 5×10^8 cycles, or such of these as can be derived from the original source of the information. The material and its condition are quoted, together with the results of static mechanical tests where these are available. The nature of the fatigue test is specified by the type of stressing employed, the ratio of minimum to maximum stress in the cycle, the type of notch (if any) with the estimated theoretical stress concentration factor, and the diameter of the specimens employed.

However, designing to resist repetitive loading is not a straightforward matter and access to such a body of data, valuable though it is, does not open up a royal road to safe design, particularly for the aircraft designer. The best estimate of the stress conditions which an airframe must withstand in service will be a continuously varying cyclic stress pattern derived from typical records of gust occurrence and velocity. A stress spectrum, in this form, would be quite unmanageable in design, and simplifying assumptions and procedures have been devised to cope with the situation. These are described, and their use illustrated by examples, in a chapter on design; gust records are transformed into gust-magnitude histograms; and the probable behaviour of the metal under an idealised cyclic stress-time pattern is estimated by reference to the cumulative damage concept of fatigue failure. This theory assumes that any given number of stress cycles of a particular magnitude will consume a fraction of the life of the component represented by the ratio of this number to the number of equal stress cycles which would cause failure, and that this principle would also apply to subsequent stressing at different stress levels. The various fractions of the whole life consumed at different levels of applied stress are thus assumed to total unity, irrespective of the sequence in which the different stresses are imposed. The limitations of the design process are acknowledged by the authors when they suggest that, as a final stage in the design procedure, "much thought should be given to the broad assumptions made: the reliability of the gust data used, the validity of the cumulative-cycle-ratio theory, the assumed operational history of the airplane and the many other factors which are far from being established as reliable." This cautionary attitude pervades the whole of the book and, in view of the section of industry towards which it is primarily directed, is both justifiable and commendable.

Notwithstanding the unavoidable deficiencies of the method, the authors have performed a much-needed service in drawing up this concise description of a design procedure, supplemented by adequate experimental data. However, in developing this main theme, they have broadened the scope of their survey to cover all aspects of fatigue of metals, so that some are accorded only superficial attention. The result is, in effect, a text-book on the general subject which, viewed in its entirety, conveys an impression of having been conceived and executed in a somewhat hurried manner. The overall effect might perhaps have been improved by concentrating more deliberately on design aspects, possibly adopting a more condensed treatment for certain of the earlier chapters.

The impression of hasty construction is heightened by one or two inaccuracies which have clearly arisen in abstracting from original published work. For example, while the authors may be quite justified in recommending the use of an elliptical relationship to estimate fatigue strengths under biaxial tension stresses (see pages 58 and 59) they are probably incorrect in ascribing the original suggestion to Gough, and are certainly in error in indicating that a curve of this form which they reproduce (page 60) comes from a paper by Stanton and Batson. Again on page 115 a simple error in copying from a paper by Phillips and Heywood leads to a mild steel being credited with a rotating bending fatigue limit of $\pm$ 84,000 lb. per sq. in. These, however, are small points and detract little from the value of the book, to the preparation of which an immense amount of effort has clearly been devoted.

COAL HAULAGE IN THE MINE

Report of the Committee on Roadway Conveyors. *National Coal Board, Hobart House, Grosvenor-place, London, S.W.*1. (2*s.* 6*d.*)

One of the biggest single tasks undertaken by the National Coal Board has been the modernisation of underground transport. In this, roadway conveyors have played an important part. The use of conveyors underground, however, is a complex matter, and until recently it had not been studied in all its aspects by any single group of experts. The present report, which is probably the most exhaustive of its kind, has been prepared by a committee appointed as a result of a suggestion made by H.M. Chief Inspector of Mines in his report on the explosion at Easington Colliery, County Durham, in 1951. The committee obtained most of their information from within the Coal Board's organisation, but the professional institutions, trades unions and the manufacturers of underground machinery were also consulted informally. The information is dealt with under five main heads: the place of conveying in underground roadway transport, safety, practical limits and economic aspects, design and operating practice, new developments.

Except where it is moved vertically, coal is transported from the coal face by rope haulage, conveying, locomotive haulage, hand tramming, gravity or other methods, or a combination of two or more of these systems. The last three are a small and diminishing part of the underground transport system, and can be ignored. At present, therefore, the choice lies between rope haulage, locomotive haulage and conveying, though new methods will doubtless come into use in the future. Conveyors can often provide the best solution to the problem of achieving greater underground transport efficiency with existing roadways and workings, and they are also frequently the best choice for a newly-planned layout. The committee recognise that on occasions enthusiasm for roadway conveyors has tended to overrun itself. Nevertheless, conveying is virtually inescapable for certain purposes, and for many others it brings great advantages in safety, efficiency and overall cost.

One of the many problems associated with the use of conveyors underground is that of safety. The committee investigated it from the three aspects of fire hazard, dust explosion hazard, and accidents to individual workmen. Nearly all conveyor fires are caused by frictional heating, and in the past the length of rubber belting on belt conveyors was a source of danger. Several types of fireproof belting are now available, and certain conveyors are in production or in course of development which are inherently fireproof. These include steel-plate and steel-band conveyors. Prevention of fire depends upon a combination of correct design, fireproof belting and correct installation and maintenance. The latter is of special importance, as it is not always easy, and may be neglected.

In the case of dust explosions it was necessary to consider factors other than those directly associated with the actual conveyors. Ventilation, for example, is involved, and so is the possibility of gas explosions, which are the most common cause of dust explosions. Prevention of spillage from conveyors, by correct design and installation, is the first step in dust suppression; this applies particularly at loading and transfer points. Installation and maintenance are all-important in the prevention of accidents to individual workmen, and greater discipline would be helpful. An important point in favour of the conveyor is that although accidents certainly do occur, it is, with the possible exception of locomotive haulage, the safest form of underground transport from the point of view of accidents to individuals.

No study of the use of conveyors would be complete without due consideration of new developments, both in production and in prospect. The duty of the conventional belt conveyor is limited by the power which can be transmitted by the belt. Belts made of steel strip or of fireproof steel-rope reinforced plastic offer one solution. On the other hand a belt of conventional fireproof material can be used to carry the load, and wire ropes or chains extending along the sides of the belt can transmit the power. Plate conveyors achieve the same result by dispensing with the belt altogether and substituting a series of steel plates each in the form of a short trough, joined together with a slight overlap to form an articulated band.

Among the important conclusions reached by the committee is the fact that no general rule is possible on the use of roadway conveyors. Whether or not a conveyor can be used safely and advantageously depends on many variable factors, and every case must be treated on its merits. It can be said with reasonable certainty that conveyors are safer than rope haulage as far as accidents to individuals are concerned, but on the other hand they are probably not as safe as locomotive haulage. Conveyors involve two major potential hazards: risk of fire and risk of coal-dust explosion. The former can be reduced greatly by the use of fireproof belting, but the latter is not so easy to remove.

The committee's conclusions are supported by a large amount of evidence, and are agreed in general by the National Coal Board. The

report is an authentic survey of the whole problem of underground roadway conveying, a subject which is of great and increasing importance. It is well illustrated, photographically and with drawings, and will obviously be of considerable interest to those engaged in the coal-mining industry. The report can also be commended to the attention of manufacturers of conveying equipment, and to others who have interests in this field.

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NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

Welded Details for Single-Storey Portal Frames. Prepared by a Committee of the B.C.S.A. *British Constructional Steelwork Association*, 94/98 *Petty France, London, S.W.*1. (2*s*. 6*d*. to applicants not on mailing list.)

As is stated in the introduction to this booklet, it is designed to give guidance on constructional details for welded single-storey portal frames, under nominally static-loading conditions, having rocker-type or fixed-type bases. Joints at the knees, apexes and valleys are discussed, as are site connections for rafters and foundations. Typical examples of such details are illustrated by sketches accompanied by an explanatory text so that a connection can be readily chosen and adopted for a particular design. The details are built up from either rolled steel sections or three-plate sections.

Bibliography of Solid Adsorbents, 1943 to 1953. By VICTOR R. DEITZ. National Bureau of Standards Circular 566. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (8.75 dols.)

The preparation of this volume was conducted as part of a programme of research under the co-operative sponsorship of the National Bureau of Standards and the Bone Char Research Project, Incorporated. It consists of an annotative bibliographical survey of solid adsorbents. As articles of commerce, the variety and number of solid adsorbents have increased markedly in the last decade; as a result, twice as many publications are cited for the decade covered by this volume as for the previous four decades. The use of silica and alumina gels, the ion-exchange synthetic resins, and chromatography are three of the most important developments now covered extensively. As has been customary with previous volumes, patent literature is not covered.

Propagation des Ondes dans les Milieux Périodiques. By LÉON BRILLOUIN and MAURICE PARODI. *Masson et Compagnie*, 120 *Boulevard Saint-Germain, Paris* 6, *France;* and *Dunod*, 96 *Rue Bonaparte, Paris, France*. (4,000 francs.)

"Wave Propagation in Periodic Structures" is based on previous publications by the same authors which have been supplemented by the results of recent investigations. Problems are studied which are of very different physical origin but where mathematical reduction leads to equations having common characteristics and very similar solutions. Some of these questions come from electro-technology and the theory of telecommunications, some have arisen in connection with studies on vibrations, and others are associated with the theory of crystal structure and the propagation of elastic, electromagnetic or electronic waves. The work is a theoretical and mathematical study providing an instructional course on the principles involved.

Arbeitsgemeinschaft für Forschung des Landes Nordrhein-Westfalen. Part 30: Forschungen auf dem Gebiet der Aerodynamik. By FRIEDRICH-SEEWALD; and **Einige Forschungsarbeiten aus der Gasturbinentechnik.** By KARL LEIST. *Westdeutscher Verlag, Ophovener Strasse* 1-3, (22*a*) *Opladen/Rhld., Germany*. (8.80 D.M.)

The above publication is No. 30 in the natural science series issued by the North Rhine-Westphalia Research Association. It reproduces two lectures including the discussions which followed their delivery at a meeting in Düsseldorf on March 4, 1953. The first deals with research in the sphere of aerodynamics and gives information showing how past developments have led to improved results. The focal point of interest under present day circumstances is then brought in and it is indicated in which direction there are prospects for further development. The second lecture is on gas turbine research. Some essential characteristics are recalled and it is pointed out where their strong and weak points lie. Possible variation in operating methods, which might be made the scope of research on gas turbines, is broadly outlined and then more detailed information is provided on work of this nature being carried out by the Institute for turbo machinery at Aix-la-Chapelle Technical College.

Théorie Générale de l'Equation de Mathieu. By ROBERT CAMPBELL. *Masson et Compagnie*, 120 *Boulevard Saint-Germain, Paris* 6, *France*. (2,400 francs.)

The above study on Mathieu's equation is intended to acquaint engineers, physicists and also mathematicians with the theory of the subject. Although this equation is met with in many branches of physics such as vibratory movements (particularly acoustics), diffraction, electro-magnetism, frequency modulation, etc., it is still considered to be insufficiently understood and therefore presents difficulties. The author's intention is to give an account of the variety of the methods employed, their interest, difficulties, scope and limitations so as to show the place which Mathieu's equation occupies in the more general class of differential equations of mathematical physics.

Champs de Vecteurs et de Tenseurs. By EDMOND BAUER. *Masson et Compagnie*, 120 *Boulevard Saint-Germain, Paris* 6, *France*. (2,200 francs.)

The theory of fields of vectors and tensors is dealt with as an introduction to its application to electromagnetism. Mathematical aspects, as well as practical application of the principles, are treated on an up-to-date basis in terms which the author has kept as simple as possible so as to divest the subject of superfluous calculations and enable physicists and mathematicians to fit actual problems into the framework outlined. The fundamental laws of Coulomb, Ampère, Maxwell and Lorentz are expressed on the basis of these simplified terms and definitions. The formulae established are then applied to electro-magnetism, and there are two concluding notes on the theory of magnetism and integration of the equation of potentials.

Cours de Physique Générale: Mécanique. By G. BRUHAT. Fifth edition revised by A. FOCH. *Masson et Compagnie*, 120 *Boulevard Saint-Germain, Paris* 6, *France*. (3,000 francs.)

This is the fifth edition of a comprehensive work on mechanics for higher scientific and technical instruction and as a reference for physicists. To a great extent it is a development of scientific instructional courses, and it maintains the character of previous editions, that is, of preparing the reader for more specialised technical or theoretical study. The main divisions are: statics, dynamics, metrology, pendulums and their movements, the mechanics of fluids, vibrations in fluids, elasticity and vibrations of solids. The text is fully supported by diagrams and formulae.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Brazing. THE BRITISH WELDING RESEARCH ASSOCIATION, 29 Park-crescent, London, W.1. An account of the potentialities, methods, advantages and disadvantages, design considerations and practical points of brazing. Illustrated booklet, the first of a series on welding and allied processes, methods and designs produced by the Research Association with aid from special U.S. funds provided by the Department of Scientific and Industrial Research.

Thermal Insulation with Sheet-Metal Finish. WILLIAM KENYON & SONS, LTD., Dukinfield, Cheshire. Typical examples of methods of covering Rocksil fibrous thermal-insulation material with sheet metals for protective purposes for such applications as high-pressure steam lines, power-station ducting, boilers, oil-storage tanks, pressure vessels, towers and columns, and valves and fittings. Illustrated brochure.

Electric Furnaces for the Wire Industry. ELECTRIC RESISTANCE FURNACE CO. LTD., 161 Queens-road, Weybridge, Surrey. Furnaces developed to meet the metallurgical needs of the wire industry, including the bell, pit pot and continuous strand types for bright annealing. Details of rod baking ovens, continuous wire patenting furnaces, electrode salt baths and controlled atmosphere generators. Illustrated brochure.

Foundry Training for Boys. F. H. LLOYD & CO. LTD., James Bridge Steel Works, Wednesbury, Staffordshire. A handbook, entitled "Moulding Men," for boys intending to become apprentices in the foundry industry, containing a description of the courses of instruction and training provided and advice to boys leaving school. Illustrated booklet.

Flameproof Distribution Switchboards. CANTIE SWITCHES, LTD., New Ferry, Birkenhead. Flameproof distribution switch boards. Details of tests at A.S.T.A. Proving Station of 350 MVA making capacity, 440 volt three-phase unit. Technical details of equipment. Illustrated pamphlet.

Distribution Accessories. W. T. HENLEY'S TELEGRAPH WORKS CO. LTD., 95 Aldwych, London, W.C.2. Ironclad service fuse for street lighting standards. Insulated double-pole service fuse for terminating twin service cables up to 0·0225 sq. in. Double-pole slow-break 30 ampere switch for single or twin cables. Technical details.

Electronic Precision Thermostat. FIELDEN (ELECTRONICS) LTD., Wythenshawe, Manchester. Electronic precision thermostat consisting of a rapid-response resistance bulb. This forms one arm of an alternating current bridge, the out-of-balance of which is amplified and used to operate a relay. Ten standard ranges. Illustrated pamphlet.

Flame Cutting Torch. BUCKLE FLAME CUTTER CO. LTD., 69 Broad Street-avenue, London, E.C.2. Detailed description and review of principal features of firm's "Paragon" torch which, when fitted with the appropriate nozzles, is capable of cutting thicknesses of materials ranging from ¼ in. to 12 in. Illustrated leaflet.

Variable-speed Alternating Current Motors. LAURENCE, SCOTT AND ELECTROMOTORS, LTD., 431 Grand Buildings, Trafalgar-square, London, W.C.2. Details of variable speed alternating current motors for the driving of boiler house and other auxiliaries in power stations. Features of general design with illustrations of actual installations.

Junction Transistors. MULLARD, LTD., Century House, Shaftesbury-avenue, London, W.C.2. Application of Mullard germanium junction transistors to hearing aids, a preamplifier and an audio-frequency amplifier. Pamphlet giving a circuit diagram, summary of performance and circuit description in each case.

Water Heater Control. M.K. ELECTRIC, LTD., Wakefield-street, London, W.18. Double pole switches for the control of water heaters and similar appliances with current carrying capacities of 30 amperes at 250 volts alternating current. Illustraded leaflet.

Heat-Resisting Castings. FOLLSAIN-WYCLIFFE FOUNDRIES, LTD., Lutterworth, near Rugby. Data regarding the mechanical, physical and other properties of "E.V." heat-resisting steel castings and "Wynite" heat-resisting iron castings. Illustrated pamphlet.

Gas Turbine. DALE ELECTRIC (YORKSHIRE) LTD., Filey, Yorkshire. Gas turbine, weighing only 1,232 lb., coupled through reduction gearing to a 50 kVA Magnicon alternator. Constructional details with scale drawings.

Barrel Anodes for Silver Plating. JOHNSON, MATTHEY & CO. LTD., 73-83 Hatton-garden, London, E.C.1. Details of cast and wrought silver anodes for use in barrel electroplating, ranging in weight from 65 to 510 oz. troy. Illustrated data sheet.

Flour Milling Machinery. THOMAS ROBINSON & SON LTD., Rochdale. All-metal purifier, redesigned for ease of operation and maintenance. Illustrated sheet for insertion in loose-leaf catalogue.

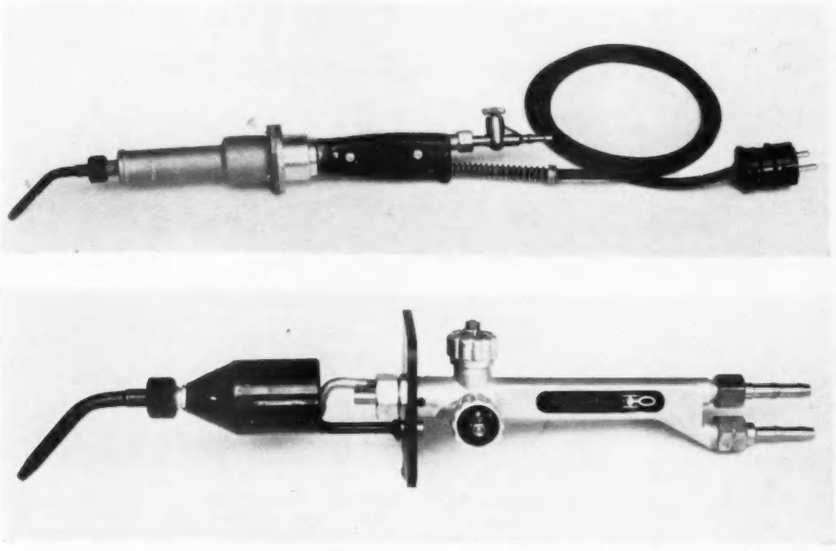
Refractory Concrete. LAFARGE ALUMINOUS CEMENT CO. LTD., 73 Brook-street, London, W.1. Recent examples of the use of refractory concrete for foundry floors and for the construction of monolithic underground flues. Two illustrated leaflets.

Conveyor Idlers. LINK-BELT CO., 307 North Michigan-avenue, Chicago 1, Ill., U.S.A. Series 50 ball-bearing conveyor idler rolls, greaseable or factory-sealed. Seven belt widths from 14 to 36 in. Folder No. 2516.

Deburring Tool. DOUGLAS KANE ASSOCIATES, 5 New Quebec-street, London, W.1. "BurrQwik" hand scraper for deburring metal parts. Two types of blade, both hooked for gripping edge of work. Illustrated leaflet.

Fuel-Oil Additives. ARMOUR & CO., LTD. (Chemical Division), Lindsey-street, London, E.C.1. Three additives for preventing sludge and gum formation in fuel oils. Properties and use given in technical bulletin No. 5.

Tractor Lubrication. MOBILE OIL CO., LTD., Caxton House, London, S.W.1. Maintenance and lubrication of tractors and farm machinery. Illustrated booklet. Available from agricultural agents.



A stream of hot air or other gas for welding thermoplastics is provided by the Griesheim gun, which can be heated either electrically (top) or by gas.

WELDING THERMOPLASTICS

ELECTRIC OR GAS HEATING

Numerous thermoplastics are now in commercial and industrial use, and various techniques have been developed for welding them. If a thin stream of hot gas at the appropriate temperature for the particular thermoplastic is directed on to the edges which are to be welded, the material will be raised to the flow or melting point, and a sound joint can be made. A filler rod of the same material as that being welded is used. The hot gas can be air for all materials which are not sensitive to oxidation, or are only very slightly so, and nitrogen for oxidation-sensitive materials such as polythene. Heating of the welding gas can be by gas or electricity, the temperature being in the region of 250 to 300 deg. C., according to the type of plastic being welded.

Both methods of heating are available in the welding guns made by Knapsack-Griesheim, A.G., Frankfurt, Germany, and marketed in this country by Horwitch Smith and Company, Limited, Pensnett, Staffordshire.

GUN DESIGN

In the gas-heated gun the welding air or nitrogen passes through a stainless-steel heater coil before issuing from the nozzle on the gun. The heating gas can be town gas, acetylene, propane or hydrogen. It is supplied to the gun through a flexible tube not exceeding 16 ft. in length. A pressure of at least 3 lb. per sq. in. is necessary for the heating gas, and for the best results the pressure should be adjustable between 3 and 7½ lb. per sq. in. Acetylene, propane and town gas all require mixing with air for combustion, and the Griesheim gun incorporates an injection mixer in the hand-piece, which takes air direct from the surrounding atmosphere.

The gun is provided with a hand shield, which protects the operator's hand from a possible burn, and also prevents waste gas from being taken into the gas jet when the gun is pointing downwards. Special vents are provided in the heating coil, which allow small amounts of air or nitrogen to escape, so increasing the pressure of the heating gases and assisting them to maintain the required direction. The vents are adjustable by means of a ring which can be closed or partly opened as required. Hand-operated valves, one for the heating gas and the other for the welding gas, are on the gun.

The electrically-heated gun is similar in appearance to the gas-heated type, takes its welding gas in the same way, and is used in a similar manner The electric heating element can be operated either direct from the mains at various voltages, or through a transformer at 24 or 42 volts. It is also possible to connect the gun through a combined unit consisting of a resistance and a small blower, which draws welding air from the atmosphere and delivers it under the required pressure to the gun. A control valve is provided on the gun for the welding gas, but it is so designed that it will not close completely. Some gas will always flow past the heating element unless it is deliberately cut off at the source, and the possibility of the element being overheated accidentally is thus eliminated. Control of temperature can be effected by means of a variable resistance in the electric circuit.

WELDING PROCEDURE

The detailed procedure for welding thermoplastics is one which must be learnt under instruction, and Horwitch Smith and Company, Limited, are prepared to train operators at their Pensnett works. Some general information can, however, be given.

A typical operation is butt, channel or corner welding of rigid polyvinylchloride. The edges must be prepared, by scraping or cutting, to an angle of 60 deg. for butt welding and 45 to 50 deg. for channel. The pieces to be joined should be 0·5 to 1·5 mm. apart, being held, preferably, in jigs. It is usual to weld from left to right, and the stream of hot air is directed at the two edges of the material and the end of the rigid P.V.C. filler rod simultaneously. The welding rod is held at an angle of 90 deg. with the material being welded, and a slight downwards pressure is applied. Welding takes place with the material in a dough-like state, and no melting path will be seen. In the hands of a skilled operator speeds of 75 to 80 mm. (about 3 in.) per minute can be maintained easily, and the strength of the joints should exceed 80 per cent. of that of the original material.

Another example is provided by the welding of overlapping seams in thick polyisobutylene sheet. With this material the edges of the two sheets to be joined are cut with an angle cutter and fitted so that they remain flat. The edge of the upper sheet is then lifted and the hot air stream is directed between the sheets with a "brushing" motion of the gun. When the material softens the sheets are pressed together and the weld completed with a special roller, several types of which are supplied by the manufacturers of th elding guns.

SILENCING PEN FOR JAVELIN

A new silencer pen, designed by the late Mr. Quentin Reeves, acoustic consultant, for running up the twin Sapphire turbojets of the Javelin aircraft, has been opened by the Hawker Siddeley Group at the airfield of the Gloster Aircraft Company, Limited, Hucclecote, near Gloucester. It enables normal conversation to be carried on just outside the pen and within a few yards of the aircraft.

The silencer consists of a 76 ft. long de-tuner made up of a series of internal baffles and an expansion chamber. The aircraft is backed into a soundproof pen formed by insulated walls 16 ft. high, so that the twin exhaust pipes are directed to the flared entry of the de-tuner. A wire-mesh protection barrier surrounds the entrance to the detuner. The pen absorbes noise arising from vibration through the aircraft wings and fuselage.

The floor of the silencer pen is of heavy reinforced concrete. There is a shallow wall for taking the nose wheel of the Javelins and fixed adjustable wheel chocks made of mild-steel plate retain the main wheels. The reinforced concrete walls are insulated with an acoustic lining faced with aluminium perforated sheeting. There are recesses in the walls for personnel and fire-fighting equipment.

For silencing the Sapphire engines of Javelin aircraft during ground testing, the Gloster Aircraft Company, Limited, have installed a silencing pen with insulated walls and a 76 ft. long de-tuner, into which the engine exhausts are directed.

AIRSLIP FORMING

A NEW VACUUM TECHNIQUE FOR THERMOPLASTICS

Fig. 1

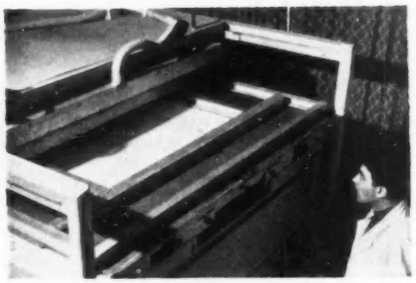


Fig. 2

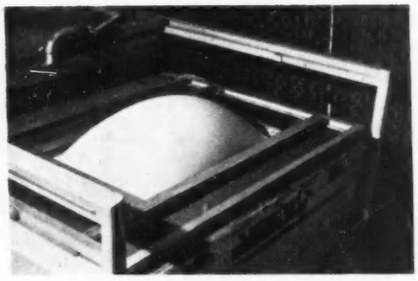


Fig. 3

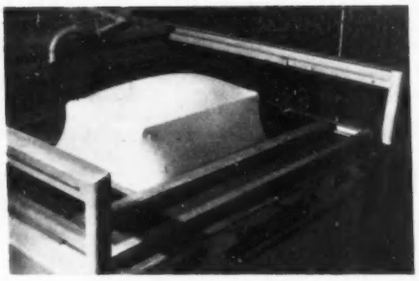


Fig. 4

The refrigerator liner shown in Fig. 7 below, is deep-drawn in a single operation from ¼ in. Saroy high-impact polysterene sheet by a new forming process, Formvac "airslip" forming, a process developed by Hydro-Chemie Limited, Zurich, Switzerland. This process is particularly suited for making the most economical use of the deep-drawing potentialities of Saroy sheet, a new product of Saro Laminated Wood Products Limited, Folly Works, Whippingham, East Cowes, Isle of Wight, made from Styron 475, a toughened grade of polystyrene manufactured by Distrene Limited and marketed by British Resin Products Limited, Devonshire House, Piccadilly, London, W.1.

The airslip forming technique was developed as a result of experiments to overcome the shortcomings of the drape-forming process over a male mould in the manufacture of deep items with more or less vertical walls. The shortcomings are as follow:—excessive edge trim resulting in higher costs, irregular gauge in the finished item, and molecular "orientation" in one direction, weakening the vertical walls.

The airslip forming technique has been developed to prevent the sheet from blocking on top of the mould and to cause it to slip over the edges and down the vertical walls. The "lubricant" which permits it to slip is hot air maintained under just sufficient pressure to lift the heat-softened sheet and allow it to slip over the edges as the mould pushes into it.

The operation of the airslip forming process is shown in Figs. 1 to 6.

In Fig. 1 is shown a sheet of high impact polystyrene being placed on the drape frame of a Formvac Model G 5 vacuum forming machine. The sheet, including clamp edges, measures 42 in. by 29 in. by 0·125 in. thick. In Fig. 2, the operator has pressed the button to lower and lock the clamp frame, and the heater is advancing over sheet. From this point, the process is automatic. On completion of heating (84 seconds), the heater has returned to neutral (Fig. 3) and the table carrying the mould is rising, compressing the hot air located under the sheet. Pressure is bled off automatically to enable the sheet to "float" above the mould. The table and mould continue to rise (Fig. 4), and the hot sheet "slips" over the edges and corners of the mould. The aluminium mould is heated to 175 deg. F. by means of hot water circulated through it by a mould-temperature regulator.

In Fig. 5, the table has completely risen and the vacuum has automatically been applied, drawing the hot sheet against the mould surfaces. Air between the sheet and mould has been exhausted in a fraction of a second through a 3 in. diameter hose and solenoid valve into a 160 gallon vacuum tank. The manufacturers claim that the mould vents, in the form of long slots 0·02 in. wide, give more rapid evacuation and consequently more successful forming than the small holes advocated by many.

Vacuum is applied until completion of the cooling cycle—52 seconds—after which it is replaced by compressed air, at a preselected pressure and speed, to release the formed sheet from the mould, the latter being withdrawn at preselected speed (Fig. 6). Only now is it necessary for the operator to intervene; he opens the clamp frame by pressing a button, removes the finished article, re-loads a blank sheet and repeats the process. The total cycle time is 150 seconds. The gauge tolerance on the finished item is accurate to within ±10 per cent.

HIGH IMPACT PLASTICS SHEET

The new toughened polystyrene sheeting, Saroy, from which the refrigerator lining has been formed, is available in sheets 48 in. wide by 100 in. long in 13 thicknesses from 0·020 in. to 0·140 in. with a matt surface both sides; and 40 in. wide by 100 in. long in 11 thicknesses from 0·040 in. to 0·140 in. with high gloss surface on one side and a matt surface on the reverse side.

Saroy sheet has excellent forming properties, as evidenced by the illustration; it has three to five times the impact strength of general purpose polystyrene; ten times the elongation of ordinary polystyrene; good dimensional stability; low water absorption; good durability; is non toxic, and is reasonably priced.

The physical properties, given in the table below, are similar in all directions.

TABLE I.—*Physical Properties of Saroy.*

Tensile strength, lb. per sq. in	3,200—4,000
Elongation, per cent.	10—20
Modulus in tension, 10^5 lb. per sq. in.	3·3—3·8
Impact strength, Izod notched, ft. lb./in. of notch	0·8—1·2
Thermal coefficient of exp., in/in./deg. F. $\times 10^{-5}$	4·0—4·5
Specific heat, Cal./ deg. C/gm.	0·3
Specific gravity	1·05—1·07
Dielectric constant, 10^6 cycles	2·5—2·6
Water absorption, per cent., 24 hrs.	0·12

★ ★ ★

ATTACHING BRAKE LININGS

Ferodo, Limited, Chapel-en-le-Frith, Stockport, have developed a method of securing linings of thicknesses of ¾ in. and over to external contracting and internal expanding brakes on colliery winders, winches and other heavy engineering plant with the object of reducing the time taken to effect replacements.

To do this friction linings up to a maximum length of 24 in. are used and are grooved to take one, two or three metal strips which are bonded in position flush with the non-working surface. The linings are slotted at the edges so that countersunk bolts can be inserted or removed when they are in position on the shoe.

It is claimed that the advantages of the Ferobond system, as it is called, are quick replacement with a minimum disturbance to plant, that the wear is small, and the amount of wear always visible so that there is no risk of damage to the brake path. Finally, the recesses for the bolts allow the products of wear to escape, thus eliminating scouring.

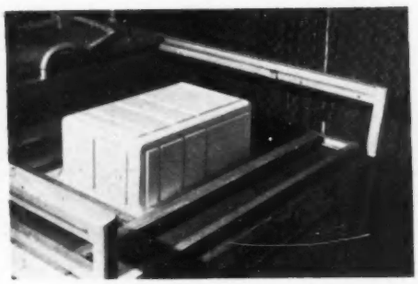


Fig. 5

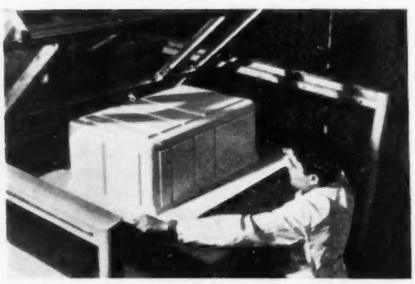


Fig. 6

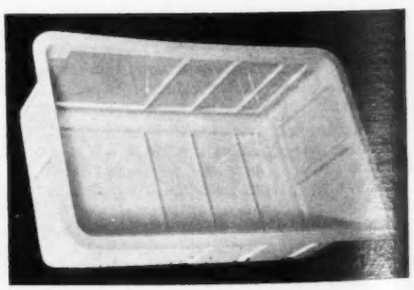


Fig. 7

Figs. 1 to 7 Stages in the forming of a refrigerator liner by the airslip process which employs a hot-air stream as a "lubricant" between the mould and the plastics sheet being shaped.

Fig. 1 A typical pocketing operation with a Wadkin heavy-duty articulated arm radial router; with a 12½ h.p. head, metal-removal rates of 20 cub. in. per minute are easily achieved; the machine can also be used for profiling.

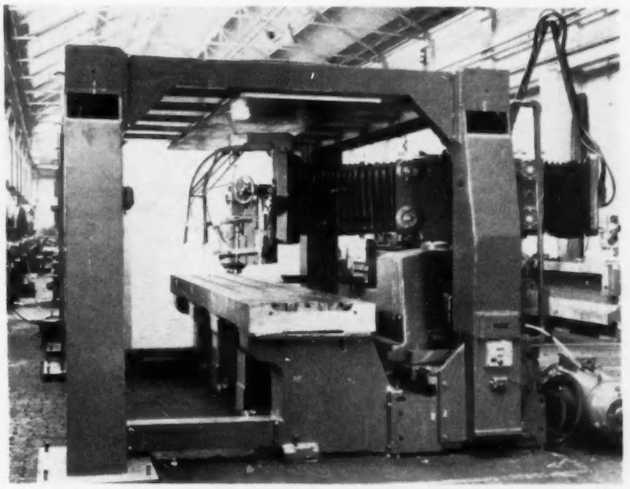


Fig. 2 The Wadkin heavy-duty overhead-template routing machine takes work up to 12 ft. long by 2 ft. 6 in. wide at one setting.

The Machine Tool Industry (continued from page 541)

In the continuation of our article on the machine-tool industry we shall deal with the following topics: machining light alloys, spark erosion, welding equipment, and milling, drilling and boring. The last subject will be covered in several parts; the first section, which is included in this issue, is devoted primarily to drilling. A previous article was concerned with automatic control systems. Many of the items discussed are on view at the International Machine Tool Exhibition, Olympia.

MACHINING LIGHT ALLOYS

HIGH METAL-REMOVAL RATES

Within the last seven or eight years, machining light alloys has become one of the aircraft industry's major production problems, as heavy-gauge skins and substantial light-alloy forgings have taken the place of lighter-gauge built-up structural components. There are two ways of tackling this problem: by the provision of highly specialised machine tools, such as complex contour-milling machines, and vast skin-milling machines of the type that have been installed in a number of American companies for the milling of complete integrally-stiffened wing skins; or by the development and adaptation of more standard machine tools that have applications in other fields besides aircraft construction.

In the first method of approach, British tool-makers have only recently begun to contribute in a small way to solving the problems of the aircraft manufacturers and all pioneering work has originated on the aircraft side. The aircraft manufacturers and the Ministry of Supply are themselves partly responsible for this absence of co-operation, through indecision and lack of a policy for ordering machine tools which, in these specialised applications, are extremely costly to develop; the conservative machine-tool manufacturers of Britain are reluctant to indulge in such effort on a speculative basis.

The second method of approach—the adaptation and development of existing techniques—has, on the other hand, resulted in a fruitful co-operation between one particular aircraft firm and one particular British tool-making concern—the Supermarine Division of Vickers-Armstrongs (Aircraft) Limited, South Marston, Wiltshire, and the well-known woodworking tool manufacturers, Wadkin Limited, Green Lane Works, Leicester. The collaboration between these two firms has led to an extension of the application of high-speed routing techniques to metal-cutting that was quite unforeseen ten years ago.

The development of router-milling techniques originated some two or three years ago when Wadkin introduced a heavy-duty radial arm router with a 5 h.p. head intended for profiling light-alloy plates up to ⅞ in. thick without preliminary rough band-sawing to shape. Vickers-Armstrongs saw in this machine, with its high spindle speeds of 12,000 and 18,000 r.p.m., used in conjunction with machine fixtures of their own design, possibilities for machining light-alloy forgings, and as a result of their work Wadkin have introduced a more powerful head and machines of sturdier design and wider application. Such machines, in use at Vickers-Armstrongs, have produced work to the same accuracy as with copy-milling machines, and at a much faster rate.

HIGH-SPEED ROUTER MILLING

Some of these advanced heavy-duty routers are to be seen on the Wadkin stand at the International Machine Tool Exhibition now in progress at Olympia. An articulated radial arm router with a 12½/10 h.p. head and spindle speeds of 18,000 and 12,000 r.p.m. has been introduced, working to close limits of accuracy when face milling or when working off the bottom of the cutter to an accurate depth. With this machine there is less tendency for the head to deflect vertically when working at the extreme limit of the radius, as compared with the simple sliding-arm type of radial router. The large hinged arm mounted on heavy ball races also provides a smooth even movement of the head which is more easily controlled over large areas. The head is operated manually, using when necessary templates secured over the job to control the profile. Because of the high cutting speeds employed, free cutting is achieved, permitting any shape to be followed without difficulty, and there are no undue cutting stresses. The applications of this machine include pocketing from the solid, as shown in Fig. 1, internal or external profiling, shaping and piercing plates or sheets in multiples, and face-milling castings—in fact, it has uses in any branch of engineering employing non-ferrous components. Metal removal rates of 20 cub. in. per minute are easily achieved.

Another high-speed router is the heavy-duty overhead type L.Y.R.3 (Fig. 2). In this, the routing machine is mounted on a saddle on a long bed and is power-traversed along a table fixed to the bed having a working surface of 12 ft. 8 in. long by 2 ft. 6 in. side. The template controlling the cutting action is carried overhead on a structure supported by four vertical pillars. The chief advantage of this arrangement is that attaching and detaching the templates to each individual workpiece is avoided, with considerable savings in time. It also permits work up to 12 ft. long by 2 ft. 6 in. wide to be machined at one setting. Where it is required to machine longer components without resetting, as on aircraft skin milling, provision is made for a second complete unit to be joined in tandem, giving a capacity for the double machine of 25 ft., and the whole area can be machined in two operations by reversing and resetting the job on the table after one-half has been routed.

The router head is 12½ h.p. at 18,000 r.p.m. and has two separate vertical movements, one controlled by a graduated handwheel and the other by the operating handles. Accurate control of the depth of cutting is by plunger-operated depth stops and by a six-station capstan stop-bar and dial indicator. The tracer pin in contact with the overhead template is spring-loaded. This is controlled by a three-position lever on the operating handle for easy movement of the two-step tracer for roughing and finishing, or complete withdrawal for working freely without template control.

Special applications of the Wadkin high-speed router head that have been developed by Vickers-Armstrongs include a pair of radial-arm routers combined to form a skin-milling machine for large wing panels; and a hydraulic servo-operated copy-milling machine in which the operator can guide the router head to follow a complex template using only a light hand pressure.

UNIVERSAL MILLER FOR LARGE ITEMS

Reverting to the Wadkin exhibits at Olympia, their new general-purpose universal milling machine (Fig. 3), first developed in the intricate milling operations on large non-ferrous components, laminated materials, and plastics, can also be used for working ferrous metals by the use of interchangeable cap heads. It is particularly suitable for accurate work on metal patterns and for use in machine shops for face-milling, profile milling, and contouring for die-sinking.

Four basic spindle speeds are provided, ranging from 500 to 3,000 r.p.m., which can be reduced by the addition of the cap heads to 30 to 180 r.p.m. or 165 to 1,000 r.p.m.

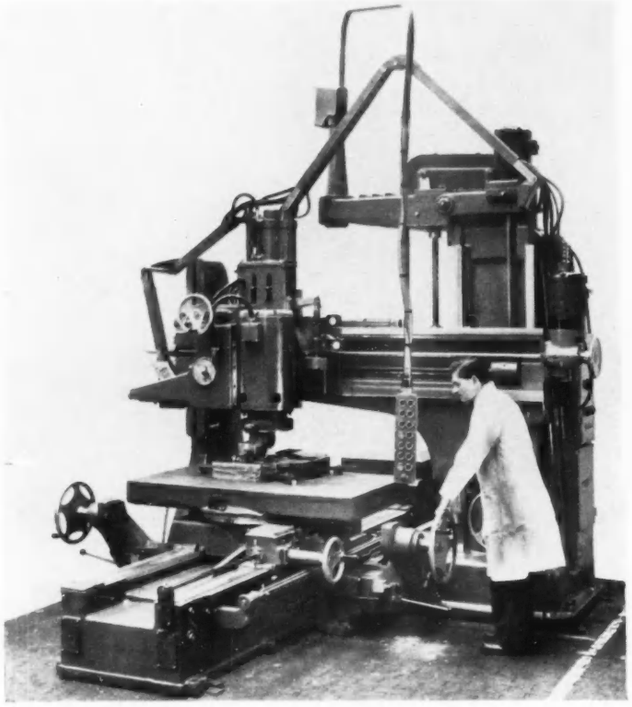


Fig. 3 The Wadkin universal milling machine can be used for ferrous metals, as well as non-ferrous, by the use of interchangeable cap heads.

A full range of power-operated movements are provided to the spindle, comprising rise and fall, vertical down feed and cross traverse. The spindle can also be canted through 120 deg. The table has a working surface of 5 ft. by 3 ft. and will accommodate a 3 ft. high component under the cutter spindle. The table rotates through 360 deg. and, when this movement is employed, work up to 5 ft. long by 5 ft. wide by 3 ft. high can be machined. The longitudinal power movement of table is infinitely variable from 1 in. to 100 in. per minute. Hand-operated motion by large handwheels is also provided.

Hydraulic-copying equipment can be supplied to special order to cover 6 in. vertical movement. It can also be applied for controlling the movement of the cutterhead across the table on the horizontal arm. Double rotary copying tables are available and when used in conjunction with the hydraulic contouring are suitable for machining round dies or opposite-hand patterns.

Another Wadkin non-ferrous milling machine with electronic control and spindle speeds of 6,000, 9,000, 12,000 and 18,000 r.p.m., was mentioned in a previous article in ENGINEERING June 22, on the electronic control of machine tools.

SPECIAL TOOLS FOR AIRFRAME MANUFACTURE

Departing now from the Machine Tool Exhibition at Olympia, and turning back to take a quick look at two of the special-purpose tools that have been evolved in the United Kingdom for cutting away large quantities of light alloy material: considering firstly the problem of producing complete integrally-stiffened wing-skin panels, the American solution of large and costly skin-milling machines for producing such panels in the flat from thick sheet material has not recommended itself to British manufacturers. Their approach is tending, rather, towards the use of slab material rolled to the requisite dimensions, then stretch-levelled to distribute the locked-up stresses, and machined to contour on both surfaces by means of an "aerofoil generating" machine tool involving the removal of up to 90 per cent. of the original slab. Stretch-levelled slab material, although not yet available in the United Kingdom, is likely to be in about 12 months' time, when the Northern Aluminium Company, Limited, will have a new stretcher press in action; and, as announced recently by the Ministry of Supply (and reported in the June 22 issue of ENGINEERING) an aerofoil generating machine tool for working slab material is now under construction at the works of W. L. Jameson, Limited, and should be completed in about a year, embodying some of the ideas worked out by two aircraft companies (Armstrong Whitworth and Boulton Paul) in earlier studies on wing-panel machining.

The other machine tool to which we wish to refer is the "Green Linnet" copy miller (Fig. 4) made by the Fairey Aviation Company, Limited, Stockport, designed in the first place for roughing-out heavy chassis ribs from stretch-levelled slab material, and incorporating two high-speed milling heads of the company's own design.

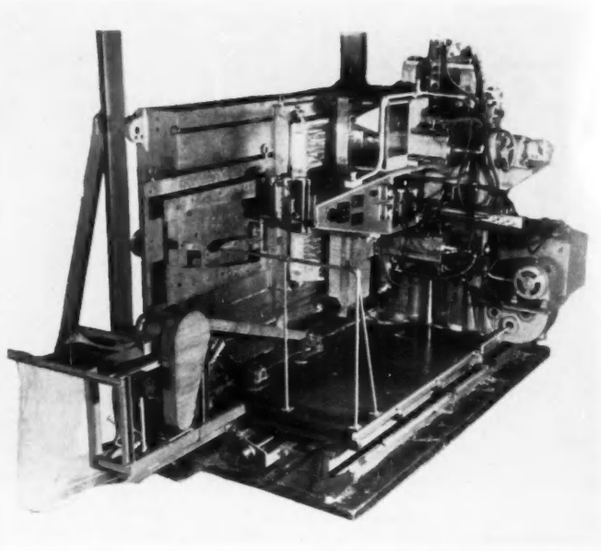


Fig. 4 The Fairey copy-milling machine embodies two high-speed heads with cutter performances of 4 to 7 cub. in. per h.p. per minute.

Fairey's have devoted considerable research to cutting light alloys, and, using carbide-tipped cutters of the face-mill type with oil-mist lubrication, they have obtained cutter performances of 4 cub. in. to 7 cub. in. per h.p. per minute. The high speed heads in the "Green Linnet" are rated at 10 h.p. at 3,000 r.p.m.; the machine, of the vertical column type, has a 6 ft. longitudinal traverse and a 2 ft. vertical movement, the latter being hydraulically tracer-controlled while the longitudinal traverse, actuated hydraulically, is controlled by limit switches. Two ribs are machined simultaneously, 230 lb. of metal being removed in 4 hours. To remove the very large quantity of swarf, a conveyor belt is provided. A further development under way at the Fairey works is the construction of a large three-dimensional programme-controlled milling machine using the Ferranti electronic control system.

The Machine Tool Industry

SPARK EROSION

Since the last Machine Tool Exhibition a new class of machine has reached the commercial market. It has always been maintained that for every poison there is an antidote and the poison of hard metals which were unmachinable by most mechanical techniques has been met by the antidote of spark erosion. Five firms are displaying machines, both from this country and abroad. Spark erosion has been developed into an extremely accurate process, capable of making very small holes or of producing large dies which require no further machining. Moreover, the nature of the material offers no problems—the technique is equally applicable to mild steel or carbides. In a similar category are the machines which use ultrasonic vibrations for drilling or die sinking—they also operate regardless of the material and indeed they can be used on glass and other non-metals.

Wickman Limited, P.O. Box No. 44, Tile Hill, Coventry, are showing two models of the "Erodomatic" machine which uses spark erosion. The first is rated at 6·6 kVA and has a separate control cubicle. The second, rated at 2 kVA, has the controls integral with the machine body. The former has a work-table 10 in. by 7 in., allowing a maximum work-piece area of 14 in. by 9 in. The quill is 12 in. distant from the table. The second machine has a larger capacity, the table being 16 in. by 12 in. and the work-piece size 29 in. by 18 in.; the quill distance is 26 in.

The "Eleroda" model D.1 spark erosion machine, which is being exhibited by the Rockwell Machine Tool Company Limited, Welsh Harp, London, N.W.2, is shown in Fig. 1. The machine has been designed and made at Ateliers Des Charmilles S.A., Geneva. It is claimed that this is the first spark erosion machine built like a machine tool and having the following design features. The electrical equipment has been carefully designed with a view to obtaining correct spark shape. The machine is compact and all necessary controls are clearly marked and simple in operation. The work head is vertically adjustable by means of a hand wheel along precision slides, which are part of the main column of the machine. Built into the head is a stable electro-hydraulic servo mechanism feeding the electrode towards or through the work, maintaining a constant pre-set voltage gap. The mechanical rigidity of the machine is such that very accurate work can be carried out easily. The machine is equipped with compact table and scales reading in 0·001 in.; thus it is not only an easy matter to locate the electrode to the work accurately but it is also possible, by means of one electrode, to spark erode two or more holes accurately at a pre-determined spacing. A clear-view safety guard is fitted in such a way that current can be applied to the electrode only when the guard is in position. The machine develops up to 1½ kW on the electrodes, the total power consumption being

½ kW. By means of a rotary switch fitted on the side of the column, six distinct speeds can be set, each speed being inversely proportional to the desired surface finish. In addition, 20 power outputs can be selected from a dial, also fitted on the control panel. At the lowest rate, i.e., the one giving highest surface finish, the machine operates at approximately 1½ megacycles—the pulses are so shaped as to represent almost instantaneous quenching of the spark. As a dielectric medium, paraffin is used; a tank and pump are therefore provided as well as a tank surrounding the table and work-piece. The design of the electrical equipment is such that virtually no maintenance should be necessary, there being no electronic valves employed. However, the complete control panel, which is hinged, with its switches and fuses can be swung from the machine, thus making all electrical components easily accessible.

Illustrated in Fig. 2 is the " Agietron " spark erosion equipment made by Agie of Locarno and shown by Pearson Phillips Limited, 194 Finchley-road, London, N.W.3. One model, the UFE 101/2K, has been in use for some while, and various improvements have been made, such as the reduction in electrode consumption. A new design, the 103/1K (as illustrated) has been introduced and was shown for the first time at Hannover. As may be seen, it is a bench-mounted model and is complete with generator and circulating pump. It is particularly suitable for fine dimensions, having a practical range of working from 0·1 mm. to 25 mm. in diameter, or sections from 0·0075 sq. mm. to 500 sq. mm. Control is fully automatic, governing the spark gap, electrode consumption and surface quality. The average depth of roughness on a finished surface is 1 μ—which means that subsequent machining is usually unnecessary. No valves are used in the generator. All metals can be machined on this model, including nitrided steels and nimonic and other alloys.

The most recent model of the " Sparcatron "—the mark III—shown on the stand of Burton, Griffiths and Company Limited, Mackadown-lane, Kitts Green, Birmingham 33, is an advance on earlier models, one of which was described in ENGINEERING, vol. 178, page 698 (1954). The mark III, illustrated in Fig. 3, has been built for simplicity and ease of operation, and in addition operates from three to eight times as fast as the mark II.

Maintenance of both the electrical and mechanical sections of the machine has, been reduced and all valves have been eliminated from the servo control in the main control and auxiliary control cabinets.

Due to the new electrical circuit and the new servo motor control, the machine is said to be stable in operation, requiring no skilled setting by the operator. For ease of operation, the servo head is now raised and lowered by a hand wheel situated at the operator's right hand, and that popular feature of previous models is retained whereby the servo head can be swung aside to allow for the easy handling of heavy dies. The arrangement of the servo head in which the ram is positioned between two sets of balls operating in V-slides to ensure perfect accuracy, now incorporates an accurate stroke limit switch which can be quickly set so that the current is automatically cut off when the electrode has penetrated to the predetermined depth.

Throughout, the design is rigid and robust, the main column for the servo head being 5 in. in diameter, and the sleeve of the bracket supporting the head is 10 in. long, while the base on which the compound table is fitted is heavily webbed and capable of carrying a weight of over 500 lb. The table tank has been increased in size to allow easier positioning of dies, and the settling tank in the base of the cabinet has been increased in capacity and incorporates an arrangement of baffles to avoid debris from the machining operation being re-circulated through the pump. The main control unit is rated at 6·5 kW and can be used on 220 to 250 or 340 to 440 volt mains at either 50 or 60 cycles. Four heads can be operated from one main unit.

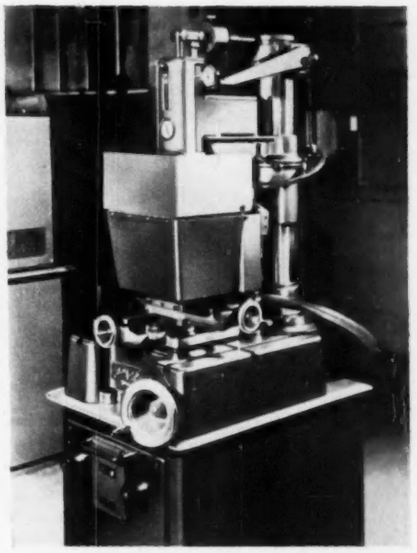


Fig. 3 " Sparcatron " spark erosion machine. (Burton, Griffiths & Co. Ltd.)

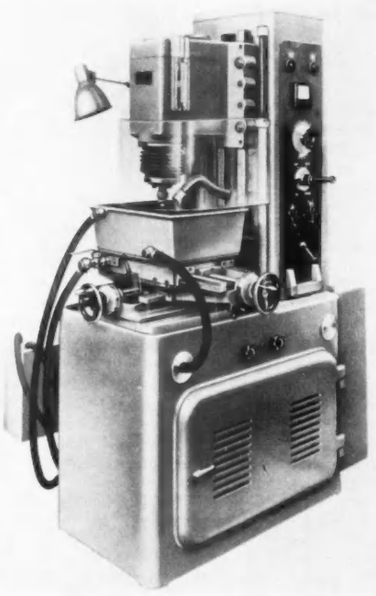


Fig. 1 " Eleroda " spark erosion machine. (Rockwell Machine Tool Co. Ltd.)

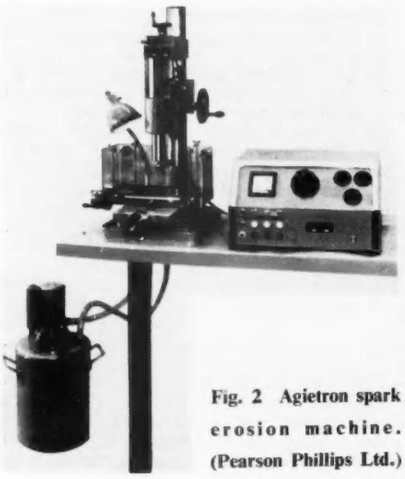


Fig. 2 Agietron spark erosion machine. (Pearson Phillips Ltd.)

The Machine Tool Industry

WELDING EQUIPMENT

The purist may limit his definition of machine tools to the operations of cutting and forming, but like the organisers of the International Machine Tool Exhibition we shall be more catholic in our coverage and include welding equipment in the present series of articles. We therefore give below descriptions of a multiple electrode welder with automatic positioning, so continuing our theme for the series of automatic operation; a welding positioner; a welding gun with a comprehensive water-cooling system; a bandsaw butt welder; and a gun for stud welding. Some, but not all, of the equipment is on show at the exhibition.

MULTIPLE ELECTRODE WELDER

Fig. 1 shows a multiple electrode plant, which is being manufactured by Sciaky Electric Weld-

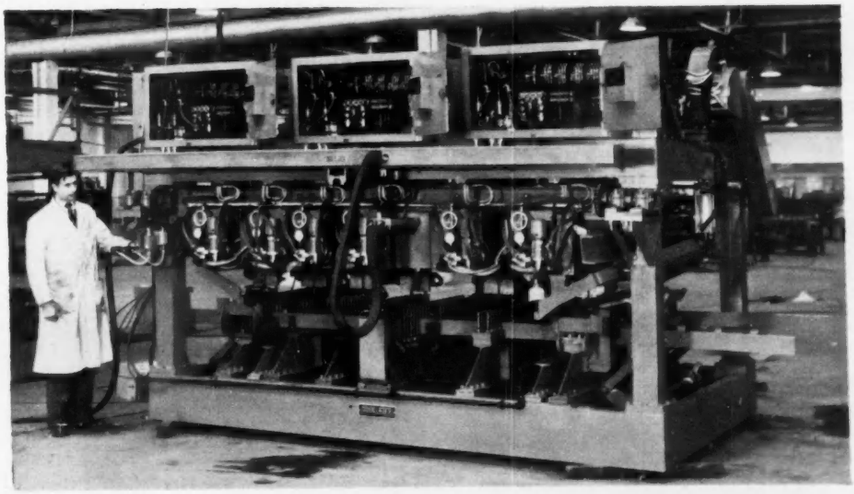


Fig. 1 Multiple electrode spot welder for large sheet-metal assemblies. (Sciaky Electric Welding Machines, Ltd.)

Fig. 2 One ton welding and assembly positioner. (Courtburn Positioners, Ltd.)

ing Machines, Limited, Farnham-road, Slough, for spot welding large sheet-metal assemblies. This plant, which is known as the Permutation welder, has been designed to utilise the advantages of multiple-electrode operation in relatively small scale production; among them being the fact that the welds are positioned automatically and not left merely to the judgement of the operator.

An example of the work for which this plant is designed is welding the floor of a commercial vehicle to its chassis. Instead of using a separate electrode for each of the 514 welds that were necessary in a particular case, two machines were employed, one to secure the cross members of the chassis to the floor and the other to weld the longitudinal members.

The first machine consists of a mild-steel frame and a moving beam on which six transformers and 12 pneumatically-operated welding heads are mounted. This beam can be traversed across the width of the floor by Geneva gearing in steps of 1¼ in., thus providing 38 welding positions. Twelve welds can then be made at each position. As the "series" principle is used the back-up electrodes are only used to carry the current from one pair of welding electrodes to the next.

The compressed air supply to the 12 welding heads is controlled by six independent electrically operated valves. There are also six commutator bars, each of which is provided with either conducting or non-conducting buttons. These buttons are arranged in such a way that when all the 12 welds are not required the desired number can be selected and fitted to the commutator bars. The duration of the weld is controlled by Sciaky timers and the primary current is switched on by ignition contactor units.

When the welding of the floor members to the chassis has been completed the work is moved to the second machine on which the remaining welds are made between the floor and the chassis side members. The system of operating this second machine is similar to that of the first except that four welds are made, that is two per station, on each of the long side members. Once the cycle of operations has been initiated both machines work automatically. They are also shut down automatically by limit switches when the welding has been completed.

It is claimed that machines of this kind can be utilised on many classes of assembly work, particularly where large numbers of irregularly and intermittently spaced welds are required. For the purpose described, about 514 welds can be produced at the rate of 12 per hour, a figure which is determined by the slower of the two operations. With other arrangements 664 welds could be produced at the same rate.

WELDING POSITIONER

Courtburn Positioners, Limited, Goldington Bury, Bedford, are now producing a welding and assembly positioner to accommodate loads up to 1 ton. This device, which is illustrated in Fig. 2, is loaded and clamped by rotating the work and top plate manually as a unit. A screw jack, which is attached to the rotation shaft then raises the top plate until the centre of gravity of the workpiece is intersected by the axis of the main shaft, thus bringing the work into balance. The jack is next disengaged by withdrawing a spring-loaded locking pin when the work can be rotated or tilted to any position by hand. Both movements can be locked by spring-loaded plungers and any dangerous movement of unbalanced loads can be prevented by a friction brake.

The tilting shaft is placed at such an angle to the main shaft that when the top plate is inverted any welding positions on the underside of the work-piece, such as flanges, are in the correct downhand position. The maximum load capacity of the standard machine with a 22 deg. work arm is from 1 ton at 6 in. centre of gravity to 1 cwt. at 31 in. centre of gravity from the top plate.

COMPREHENSIVE WATER COOLING

Among the products of A.R.O. Machinery Company, Limited, 18 Madrid-road, London, S.W.13, is the welding gun illustrated in Fig. 3. This is entirely water-cooled, not only the transformer and the tips of the electrodes being treated in this way, but also the electrode holders and the braided lead which connects them to the transformer. It is claimed that all hot points are thus eliminated and that work can be carried on continuously without overheating on the heaviest gauges for which the machine is designed. A further point of interest in the gear is that in order to increase the opening between the holders it is only necessary to operate a lever on the movable grip.

The weight of the welder is 25 lb. and it is capable of making 4,000 spot welds per hour between two No. 20 s.w.g. sheets, the forging pressure being 265 lb. and the secondary current 9,000 amperes.

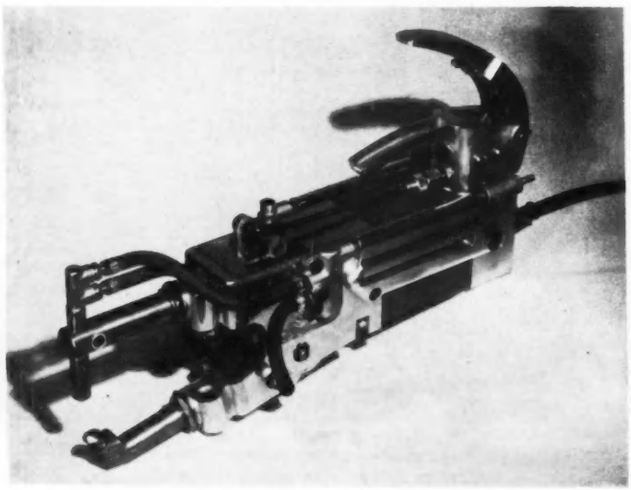


Fig. 3 Water-cooled welding gun. (A.R.O. Machinery Co. Ltd.)

BANDSAW BUTT WELDER

Fig. 4 is an illustration of a butt welder for bandsaws the manufacturers of which are the Midland Saw and Tool Company, Limited, Midsaw Works, Pope-street, Birmingham, 1. As will be seen, the panel from which the mechanism is controlled is flush mounted on the stand. It carries two knobs one of which operates the electrical and the other the mechanical equipment. The electrical control has five positions which are used for settings when saws from ⅛ in. to 1 in. wide are being dealt with. In addition, there are three annealing positions for the same range of work. The mechanical control enables the pressure applied to the moving clamp to be infinitely varied. A lever, which pre-sets the pressure applied to the moving jaw is also mounted on the panel, on the lower half of which is a guillotine-operated lever and a filing post.

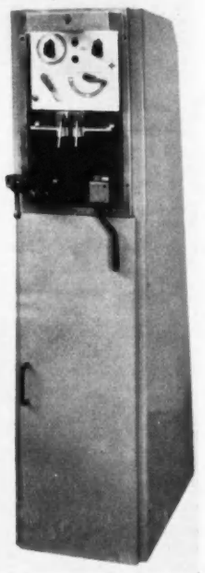


Fig. 4 Bandsaw butt welder. (Midland Saw and Tool Co. Ltd.)

The design is such that up-setting is entirely automatic and that the cuts made by the guillotine at the ends of the saw are square, experience having shown that a stronger joint is obtained in this way than by grinding. Grinding, in fact, has the disadvantages that overheating may occur and that the operation may take place on a joint that has not been properly annealed. With a guillotine, too, it is quicker to file the surplus off the joint and a better finish is obtained in this way. The welder is arranged for connection across two phases of a three-phase supply.

An improved gun for stud welding is being shown by Philips Electrical Limited, Century House, Shaftesbury-avenue, London, W.C.2. The barrel is now hollow so that the reverse ends of the studs can be accommodated inside. This allows the use of studs from ¼ in. to ½ in. diameter up to a maximum length of 8 in. Special studs are not required. A high degree of accuracy in placing the studs is possible, since the support leg is fitted with a positioning foot, the edges of which are bevelled so that the hairline register marks can be perfectly aligned with centre-lines scribed on the workpiece. When the gun is loaded, the amount by which the stud projects beyond the plane of the support leg tups affects the quality of welds. To permit ultra-fine control of this distance, therefore, the gun is now fitted with a vernier adjustment.

The Machine Tool Industry

DRILLING, BORING AND MILLING

Any review of present-day drilling, boring and milling machines must inevitably lead to a review of automatic control, for these machines, in their simple or specialised forms, make up the bulk of most production lines. Automatic control in this sense ranges from a simple mechanical stop and trip mechanism to the most elaborate arrangement which employs a computer to read a punched tape and transmit the directions to the machine. Indeed the basic demand on any machine installed nowadays is that it must reduce labour—by far the costliest item in the budget and one of the most difficult to obtain This trend is well illustrated by many of the items shown at the International Machine Tool Exhibition.

The general tendency that began with the introduction of the small electric motor has continued—that is, a separate motor for each operation. This is a steady development of the motorised machine which rendered the old overhead belting unnecessary, offering more economical operation with reduced risk. The use of hydraulic power to operate feeds has also increased, although this is being challenged by electronic control. There is no doubt, however, that for machines designed for the production line, power operation of the feeds is now a "must."

DRILLING

An interesting trend emerges from the desire to save capital cost; it is that the tendency for machines to become highly specialised has been halted and indeed reversed. Most machines in a production line nowadays are basically general forms that have become specialised by the addition of attachments. Such changeable attachments allow each machine to perform many different operations and also allow a large degree of standardisation of the "power unit." This is probably particularly so in the case of the drilling machine, which has become a real "jack of all trades." It can now be regarded in fact as the key machine of the factory. Attachments enable it to carry out drilling, reaming, tapping and counterboring in clear or blind holes. Associated with this trend is the tendency for supplying separate drilling heads which can be mounted in groups as desired, and the arrangement of which can easily be changed to suit a change in product. Exhibitors of such heads include Kitchen and Wade, Limited, Halifax; James Archdale and Company, Limited, Worcester; and Gaston E. Marbaix, Limited, Devonshire House, Vicarage-crescent, London, S.W.11. Most of these units incorporate—as do the main machines—automatic feeds which give fast approach, slow cutting and fast withdrawal, all of which come into play automatically once the cycle has been started. One unit, for horizontal mounting, is shown in Fig. 1.

AUTOMATIC TRANSFER

Several unit heads have been built up with other items to form a transfer machine of standardised construction exhibited by James Archdale. This employs the method of transfer in which the workpiece is mounted on a platen that acts as carrier and locator during the passage through the machine. Such a system is employed by A.E.C. Limited, Southall, and was described in ENGINEERING, page 53, *ante*. Swarf and platen-return conveyors are included in the exhibit.

Still holding its own amid all the specialist requirements, is the sensitive radial drill. The accuracy and general usefulness of this tool still make it a conspicuous feature of almost every shop. James Archdale, for example, are exhibiting models up to 9 ft. high with a spindle radius of 12 ft. A machine of this size has separate motors for each motion—illustrating the tendency referred to earlier—and has hydraulic control. It is illustrated in Fig. 2. A newcomer to their range is a 5 ft. mechanical drill fitted with a speed pre-selector. It has two ranges of spindle speeds, from 15 to 1,500 r.p.m. or from 10 to 1,000 r.p.m., and 12 feeds. Holes up to 3 in. in diameter can be drilled in mild steel, or up to 3½ in. in cast iron. Speeds can be preselected at any time, whether the spindle is running or stationary. Pressing a button operates the change. A single lever on the column locks or unlocks both the saddle on the arm and the arm on the column simultaneously. The lock on the arm is power operated.

MULTI-SPINDLE MACHINES

Other exhibitors of drills include Kitchen and Wade who are showing several well proved machines. Their exhibit also includes two sizes of production drill presses and two 12-spindle machines, one with a fully automatic hydraulically controlled cycle giving rapid approach, slow feed, rapid return and stop; and the other having adjustable spindles with mechanical feed and lever control of feed and speed.

Another multi-spindle machine is that made by Burkhardt and Weber and shown on the stand of Stuart Davis Limited, Much Park-street, Coventry, which is illustrated in Fig. 3. It has 12 spindles, each of which has three speeds and is individually adjustable. As the main drive motor is designed for pole changing, the total range of spindle speeds available is 12, from 225 to 2,840 r.p.m. The drilling head is fed under hydraulic power giving feeds varying between 0·16 in. and 7·8 in. per min. and also a rapid power traverse. The spindles are driven through gears from a 3 h.p. flange-mounted motor and run in ball bearings. Movements of the head can be either completely automatic or under hand control as desired; the stroke is 15¾ in. The area covered by the spindles is 12½ in. by 14 in. and the minimum distance between spindles is 1·3 in.

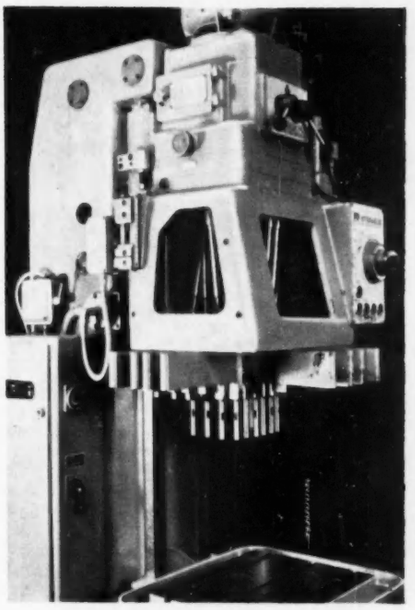


Fig. 3 Multi-spindle hydraulic drill. (Stuart Davis, Ltd.)

Complementary to the larger drills, many makers were showing bench and pedestal mounted models of medium and small capacity. Typical of one type is the Pacera range exhibited by W. J. Meddings Limited, 16 Berkeley-street, London, W.1, one of which is shown in Fig. 4. This has a capacity of ½ in., and is a redesign of an earlier model. It is belt driven. Grimston Electric Tools Limited, Progress-way Croydon, Surrey, are showing both bench and pedestal drills with capacities up to 1¼ in. A wide variety of speed ranges is available and the drive is through a constant-mesh gearbox which can be arranged to give up to 16 different speeds. The drilling heads can be supplied separately.

The same firm are also exhibiting portable

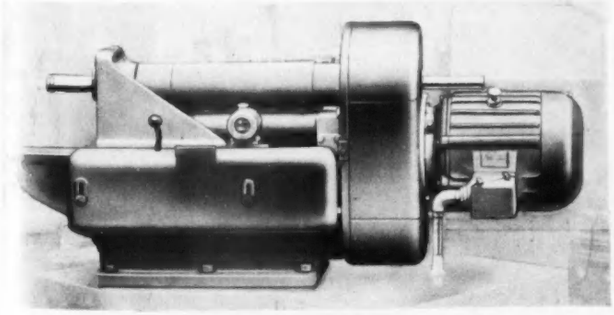


Fig. 1 Horizontal drilling head. (James Archdale and Co. Ltd.)

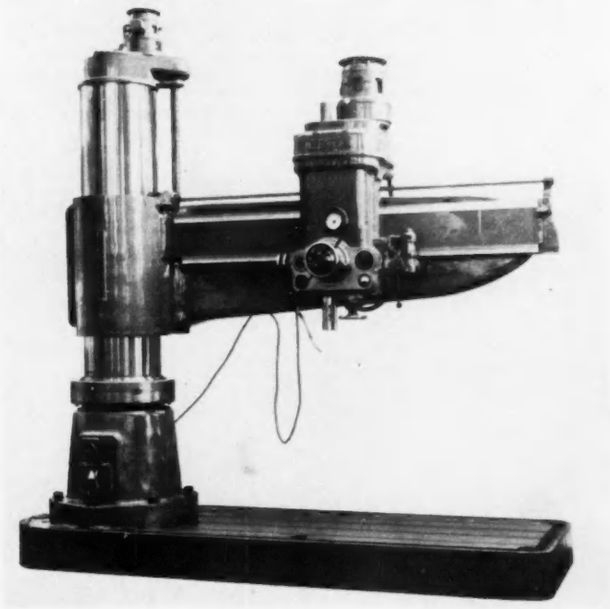


Fig. 2 Hydraulic radial drill; 12 ft. radius. (James Archdale and Co. Ltd.)

Fig. 4 Pedestal drill, ½ in. capacity. (W. J. Meddings, Ltd.)

flexible-shaft machines, as, too, are B. O. Morris Limited, Morrisflex Works, Coventry. The latter demonstrate how multi-purpose milling and drilling machines can be built up by mounting several heads, each driven by a flexible shaft, on a single pedestal so that a series of operations can be carried out. It is an extremely simple matter to unbolt the heads and rearrange when a change of work is required. Swinging arms can also be used to carry a drilling head.

TURRET-HEAD DRILL

A drill which obtains its versatility by using a turret head, is the " Burgmaster " shown on the stand of Drummond-Asquith (Sales) Limited, King Edward House, New-street, Birmingham and illustrated in Fig. 5. Two models are made, one with six and the other with eight spindles. The operation is automatic under hydraulic power, each spindle being advanced and withdrawn in turn. The cycle incorporates provision for by-passing an idle spindle, and each one can be set for speed and feed, the change-over being automatic.

Cams are mounted on the control drum which govern the rate of approach and return. Depth stops are also mounted on this drum. Rates of feed range from 0·002 in. per revolution to 0·125 in. per rev. and are controlled from separate valves. A combination of a two-speed motor and two-speed clutches with three different gear ratios, gives a choice of 12 different speeds for each spindle. All functions are under the control of push buttons which are normally used for setting up, or for emergency. The machine slide has an eight or 12 in. stroke according to the model, and the corresponding drill capacities are ¾ in. and 1½ in.

CO-ORDINATE TABLE

A device which converts any precision drill into an automatic co-ordinate setting machine is being displayed by Burton Griffiths and Company, Limited Mackadown-lane, Kitts Green, Birmingham, 33. Known as the " Jigmatic ", it is made by the Arber Grinding Machine Company and is shown in Fig. 6. It consists essentially of a work table with horizontal movements at right angles, and a control cabinet which interprets the required co-ordinates from a punched tape and moves the table into position. A digital system is used. The rectangular table has a locating capacity of 20 in. by 30 in. and measures 23 in. by 34 in. It can be mounted on almost all types of radial drill of 4 ft. capacity and above. The accuracy of positioning is within 0·001 in.

The table is controlled by a tape reader housed in a cabinet, which may be located at any convenient position as it is connected only by electric cables. Below the tape-reader head there are two doors, behind which is provided space for tape and tool storage. File slots in this space can accommodate 92 tapes. Housed within the rear of the cabinet there is the electrical panel and main disconnecting switch operated by an external handle.

The punched tape for the Jigmatic is prepared on a template-type hand punch from the engineering drawings. It is not necessary to code or convert this information in any way before punching. All hole locations are referenced from X and Y co-ordinate axes, and it is only necessary that the workpiece is located on the Jigmatic table in proper relation to these axes. As many as 200 hole locations can be punched on one length of tape. The tape is easily loaded into the reader, and there is no need to rewind upon completion of a piece. As the tape is not rewound, there is no danger of the operator loading it into the reader in any position except the correct one.

Fig. 5 Burgmaster automatic turret-head drill. (Drummond-Asquith (Sales), Ltd.)

Two standard electric motors drive the table through a system of gears and clutches. The table is moved by two precision-ground lead screws, and the drive and control mechanism incorporates an automatic mechanism to provide final positioning in only one direction regardless of the original direction of table travel. When in position the slides are securely locked by means of an electro-magnetic brake.

In operation the operator would first place a tape on the locating pins, then feed it through the slot in the reading head and on to the wind-up reel where the end of the tape is secured by a spring clamp. The loading knob is rotated from " Load " to " Run " and the " Tape Start " button is pressed. The tape then traverses through the head until the first set of punched holes is in reading position. At this juncture the operator can press the " Position " button which causes the slides to move to the position as indicated by the punched holes. When this position is reached, the red " Positioning " light goes out and the green " In Position " light is illuminated, signifying that the table is in position and locked, and the tape automatically moves into position to read the next hole location.

A detachable work table for co-ordinate setting, but without the punched tape control is also being shown by Buck and Hickman Limited, Whitechapel-road, London, E.1.

In the continuation of this article, to be published in a subsequent issue, we shall discuss boring and milling machines.

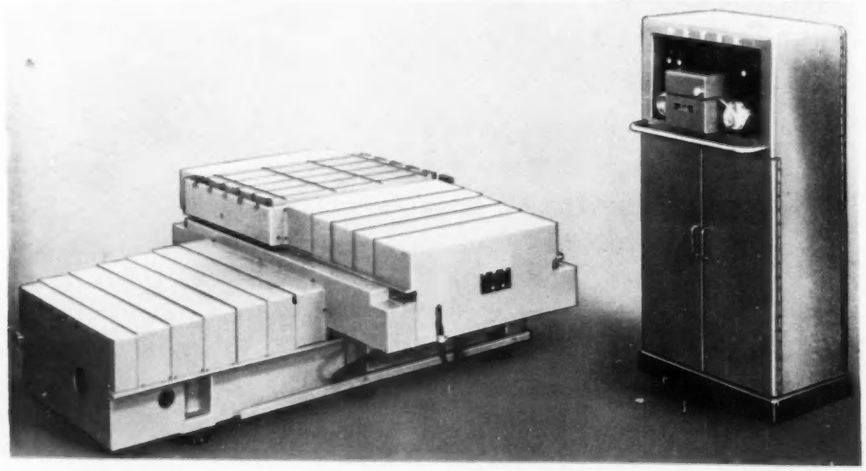


Fig. .6 Work table with co-ordinate setting by punched tape. (Burton, Griffiths and Co. Ltd.)

In describing the Jerwag climb-cut programme-control [illegible] machine (agents: Stuart Davis Limited) in the article [illegible] Control Systems published in ENGINEERING last week, [illegible] in accordance with the details supplied to us that it was [illegible] by metal tape. The machine shown at the International [illegible] Tool Exhibition at Olympia was, however, controlled by [illegible] of a slotted plate carrying adjustable dogs and fitted [illegible] of the table, as indicated in our illustration.

ATOMIC REVIEW

Civil engineering contractors join A.E.I.-John Thompson—Steps towards nuclear propulsion—Improved prospects for Britain's nuclear power programme—World reactor projects.

Company Announcements

The A.E.I.-John Thompson Nuclear Energy Company Limited, Oak House, Cross-street, Sale, Cheshire, have recently announced that Balfour, Beatty and Company, Limited, and John Laing and Son, Limited, have been appointed to the group as civil engineering contractors. The two firms are associated with A.E.I.-John Thompson in the preparation of a tender for a nuclear power station for the Central Electricity Authority. Both civil-engineering firms have considerable experience in thermal and hydro-electric power-station construction, while John Laing and Son have in addition carried out work in connection with several atomic installations—the Windscale plant and a number of uranium plants in South Africa. W. S. Atkins and Partners, of Victoria-street, London, S.W.1, are acting as consultants to the group for all civil engineering and services. The A.E.I.-John Thompson Nuclear Energy Company is thus now fully equipped to undertake atomic power station contracts, being able to carry out all the major engineering operations involved in the work.

The English Steel Forge and Engineering Corporation, Limited, are supplying a total of 4,500 tons of rolled plate for the Calder Hall and Annan atomic power stations. Six inches thick, it will form part of the thermal shielding designed to protect the concrete radiation barrier from the heat generated by the reactor. An overhead view showing the interior of the first reactor chamber at Calder Hall before completion is illustrated below. The thermal shield, which is seen under construction, takes the form of an octagonal wall 45 ft. across and 80 ft. high, with similar rolled plates forming the floor and roof, and encloses the reactor vessel itself. Vertical columns constructed from 6 in. plate are also being made by the company. These form the skeleton of the wall and hold the thermal shield plates in position. The thermal shield plates themselves are machined on their top and bottom edges, to enable them to rest one on another. The English Steel Forge and Engineering Corporation, Limited, a subsidiary of the English Steel Corporation, Limited, River Don Works, Sheffield, 9, are also making certain sections of the Calder Hall and Annan reactor vessels. The first reactor at Calder Hall became critical on May 22 last.

Propulsion

Rolls-Royce Limited, Derby, are reported to have appointed Air Chief Marshal Sir Ralph Cochrane to administer the company's nuclear research programme. He is likely to be responsible for the new laboratory which is under construction at Derby, where problems associated with marine and aircraft propulsion by nuclear means will be studied. The application of nuclear propulsion to ships is also being investigated by Vickers Nuclear Engineering Limited who are reported to be engaged on the development and construction of a nuclear vessel for the Admiralty. There is reason to believe that the ship would be a fairly large motor torpedo-boat built for cruising at high speeds. Initially it is likely to be fitted with one engine but provision may be made for the installation of a second.

The main problem associated with the use of nuclear reactors for propulsion is the weight of shielding necessary if they are to be safely operated; this applies especially in the case of aircraft. The Atomic Energy Research Establishment at Harwell is proposing to carry out investigations into shielding and other problems with the aid of the projected swimming pool reactor LIDO, a model of which is shown in the illustration below; reference to it has previously been made in ENGINEERING (pages 283, 453 and 474, *ante*). The use of light water as coolant and moderator permits the reactor core, which is suspended from a gantry, to be moved close to any one of several test assemblies or shields installed in the tank. Since the moderator is light water an enriched fuel is employed.

Power Programme

Impressions given during the fifth World Power Conference at Vienna suggest that technical and scientific studies carried out while the Calder Hall station has been under construction have favourably altered the perspective of Britain's nuclear power programme. In fact it appears from various reports that stations now to be built in Stage I are likely to be economically superior to those originally planned for Stage II. In addition, it is probable that the first stations to be erected for the Central Electricity Authority will have twice the capacity of those proposed when the programme was first announced, but will cost little more than the smaller installations.

This alone is expected to reduce the cost of electricity by one-tenth of a penny per unit and when this reduction in capital cost is coupled with anticipated lower operating costs, it seems likely that the White Paper figure of 0·76*d.* per unit for electric power from nuclear stations will prove to be a considerable over-estimate. These revelations seem to conflict to some extent with other responsible statements made during the present year, but since all figures given depend on the method of calculating depreciation—whether, for example, historic or replacement cost is considered—there may not in fact be any disagreement.

A conclusion that has emerged from the Conference and also from recent decisions and statements made by the Soviet and American authorities (see " Reactor Projects " below) is that graphite-moderated reactors cooled by pressurised gas are the only kind likely to be economic in the immediate future. Another point was that the world might have to face in 20 or 30 years a major difficulty in providing for peak loads; this problem was receiving considerable attention in Britain.

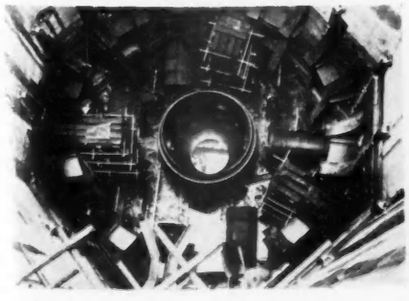
Reactor Projects

In Canada tenders have been invited for an 18MW nuclear power plant to be built within half a mile of an existing generating station at Des Joachims on the Ottawa River. Work on this atomic power station, Canada's first, is expected to begin within the next few weeks; it is due for completion early in 1959.

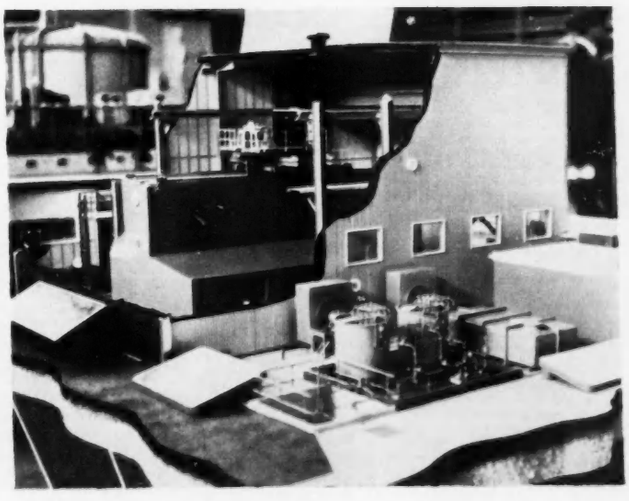
It is reported that the United States Atomic Energy Commission is to invite plans for a £1·4 million gas-cooled power reactor to be built at the National Reactor Testing Station in Idaho. Another nuclear power plant to be located near Monroe, Michigan, on Lake Erie, about 30 miles south of Detroit, is to have a 150 MW steam turbo-generator set made by the Allis-Chalmers Manufacturing Company of Milwaukee. Preliminary preparations of the plant site are now in progress and the project is scheduled for completion in 1959 or 1960.

West Germany is planning a fairly comprehensive programme of small-scale reactor construction with the help of Britain and the U.S. Large power stations, however, will not be built for the time being since, as Herr Strauss, the Federal Minister for Atomic Questions, has recently remarked, the coal situation is not as serious in Germany as in the United Kingdom. It is reported that the following installations have been considered, proposed or undertaken: an A.E.I.-John Thompson MERLIN swimming-pool reactor for North-Rhine Westphalia; a 10 MW DIDO-type materials-testing reactor, which may be built under arrangement with Head, Wrightson and Company (U.K.), for North-Rhine Westphalia; a small power-reactor to be constructed by Babcock and Wilcox (U.K.), in conjunction with their German subsidiary, for Düsseldorf; a swimming-pool reactor, to be made by the American Machine and Foundry Company, for the Munich Technical Institute; a Babcock and Wilcox (U.S.) swimming-pool reactor for Hamburg; a boiling-water reactor planned by an industrial group headed by Farbwerke Höchst, who are seeking the help of North American Aviation Incorporated, for Frankfurt University; a pilot power plant of approximately 20 MW, not yet allocated, for the utility company R.W.E. (Rhine-Westphalia Electricity); and a 10 MW research reactor, operating on natural uranium and producing small quantities of plutonium, for Karlsruhe. This unit is to be built without foreign aid and construction should begin shortly.

India's first reactor at Trombay, near Bombay, is scheduled to become critical next month and a second to be constructed with Canadian assistance is due for completion in 1958. Japan, which is negotiating for a third swimming-pool reactor, is also considering the purchase from Britain of a 100 MW power reactor, which if built, would, begin operations within five years.



(On left) Overhead view of Calder Hall reactor chamber prior to completion. Some of the 6 in. rolled steel plates forming the thermal shield, which serves to protect the concrete radiation shielding from the reactor heat, were made by the English Steel Forge and Engineering Corporation.



(On right) Model of swimming-pool reactor which will be used by the Atomic Energy Research Establishment for testing shield assemblies. It will therefore contribute to the development of reactors for propulsion.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *April 27, page 287; or May 25, page 412. Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

***Oceanographic Exhibition, International.**—June to end of August, at Marseilles. Organised by the general secretariat, C.E.A.I., 3 Avenue Saint Honore d'Eylan, Paris 16.

Machine Tool Exhibition, International.—Fri., June 22, to Fri., July 6, at Olympia, London W.14. Organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. Tel. HOLborn 4667.

Glass Congress, Fourth International.—Commencing Mon., July 2, at Paris. Apply to the secretary, Institut du Verre, 24 Rue Dourlet, Charlerot, Belgium.

Works Transport Conference.—Tues. and Wed., July 3 and 4, in Sheffield. Organised by the British Iron and Steel Research Association, 11 Park-lane, London, W.1. (Tel. GROsvenor 4751). Apply to the technical secretary, Plant Engineering Division, B.I.S.R.A., 140 Battersea Park-road, London, S.W.11. Tel. MACaulay 4421.

Royal Agricultural Show.—Tues., July 3, to Fri., July 6, at Newcastle-upon-Tyne. Organised by the Royal Agricultural Society of England, 35 Belgrave-square, London, S.W.1. Tel. BELgravia 5323.

International Union of Forest Research Organisations, 12th International Congress.—Fri., July 6, to Sat., July 14, at Oxford. Apply to Professor A. de Philippis, Instituto di Selvicoltura, Piazzale delle Cascine, Florence, Italy.

New York Lamp Show.—Sun., July 8, to Fri., July 13, at New Yorker Hotel, New York. Apply to Mr. George F. Little, 220 Fifth-avenue, New York 1.

***Society of Chemical Industry, 75th Annual Meeting.**—Mon., July 9, to Sat., July 14, at various centres in London. Organised by the Society, 56 Victoria-street, London, S.W.1. Tel. VICtoria 5215.

Duke of Edinburgh's Study Conference on Human Problems of Industrial Communities within the Commonwealth and Empire.—Mon., July 9, to Fri., July 27, at Oxford.

Great Yorkshire Agricultural Show.—Tues., July 10, to Thurs., July 12, at Harrogate. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

***Western Packaging and Materials Handling Exposition.**—Tues., July 10, to Thurs., July 12, at the Pan Pacific Auditorium, Los Angeles, Cal. Organised by Clapp and Poliak, Inc., 341 Madison-avenue, New York 17.

Physics of Some New Aspects of Non-Destructive Testing, Conference.—Wed., July 11, to Sat., July 14, at the H. H. Wills Physical Laboratory, Bristol. Organised by the Non-Destructive Testing Group of the Institute of Physics, 47 Belgrave-square, London, S.W.1. (Tel. SLOane 9806). Apply to Mr. R. S. Sharpe, Bristol Aero-Engines, Ltd., Filton House, Bristol.

Molecules in Cosmic Sources, Seventh International Astrophysical Symposium on.—Thurs., July 12, to Sat., July 14, at Liége, Belgium. Apply to Prof. Harold C. Urey, Institute for Nuclear Studies, University of Chicago, Chicago 27, Ill., U.S.A.

Industrial Co-Partnership Association's 26th Summer Conference.—Fri., July 13, to Mon., July 16, at Girton College, Cambridge. Apply to the Industrial Co-Partnership Association 36 Victoria-street, London, S.W.1. Tel. ABBey 3342.

***"Chemisorption," Symposium on.**—Mon., July 16, to Thurs., July 19, at University College of North Staffordshire, Keele, Staffordshire. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

International Society of Photogrammetry, Eighth Congress.—Tues., July 17, to Thurs., July 26, at Stockholm. Apply to Mr. P. O. Fagerholm, Bragevägen 8, Stockholm, Sweden.

Housing and Town Planning, International Congress.—Sun., July 22, to Sat., July 28, at Vienna. Apply to Mr. H. van der Weijde, secretary-general to the Federation of Housing and Town Planning, Paleisstraat 5, The Hague, Holland.

***Victoria State Fair.**—Mon., July 23, to Sat., Aug. 4, at the Exhibition Buildings, Melbourne. Apply to Industrial Public Relations Service of Australia, 82W Toorak-road, South Yarra, Victoria, Australia.

Royal Welsh Agricultural Show.—Wed., July 25, to Fri., July 27, at Rhyl. Apply to the secretary, the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

***Royal Meteorological Society, Conference.**—Thurs., July 26, to Sat., July 28, at Pantycelyn Hall, University College of Wales, Aberystwyth. In honour of Sir David Brunt's 70th birthday. Apply to the assistant secretary, Royal Meteorological Society, 49 Cromwell-road, London, S.W.7. Tel. KENsington 0730.

Australian World's Fair.—Thurs., July 26, to Sat., Aug. 4, at Sydney. Apply to the managing director, Australian World's Fair, 234 Clarence-street, Sydney, N.S.W., Australia.

Dornbirn International Export and Samples Fair.—Fri., July 27, to Sun., Aug. 5, at Dornbirn, Austria. Apply to the British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Skane (Swedish National) Fair.—Sat., July 28, to Sun., Aug. 5, at Malmo. Apply to Skanemassan Kommissariat, Stora Nygatan 15, Malmo, Sweden.

***Pacific National Exhibition.**—Thurs., Aug. 2, to Mon., Sept. 3, at Vancouver. Apply to Mr. Ben Williams, Exhibition Park, Vancouver, B.C., Canada.

Geographical Congress.—Thurs., Aug. 9, to Sat., Aug. 18, at Rio de Janeiro, Brazil. Apply to Mr. G. H. T. Kimble, International Geographical Union, 330 West Forty Second-street, New York 36.

***Radio and Electrical Appliances Exhibition.**—Wed., Aug. 15, to Sat., Aug. 18, at Dar es Salaam. Apply to the organising secretary, Radio Exhibition of Social Development, Dar es Salaam.

X-Ray Microscopy and Microradiography, Symposium on.—Thurs., Aug. 16, to Tues., Aug. 21, at the Cavendish Laboratory, Cambridge. Held under the auspices of the International Union of Pure and Applied Physics, with financial support from U.N.E.S.C.O. Apply to the organiser, Dr. W. C. Nixon, Cavendish Laboratory, Cambridge. Tel. Cambridge 54481.

***Izmir International Trade Fair.**—Mon., Aug. 20, to Thurs., Sept. 20. Apply to British Chamber of Commerce of Turkey, Piyasa Han 602-606, Asirefendi Cad. 11-13, Istanbul.

***Mombasa Trade, Industry and Agriculture Exhibition.**—Wed., Aug. 22, to Sun., Aug. 26. Organised by the Muslim Association, P.O. Box, 583, Mombasa, Kenya.

Radio Show (23rd Annual National Radio and Television Exhibition).—Wed., Aug. 22, to Sat., Sept. 1, at Earl's Court, London, S.W.5. Preview for overseas and special guests, Tues., Aug. 21. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

"Model Engineer" Exhibition.—Wed., Aug. 22, to Sat., Sept. 1, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Organised by *The Model Engineer* (Percival Marshall & Co., Ltd.), 19-20 Noel-street, London, W.1. Tel. GERrard 8811.

Canadian National Exhibition.—Fri., Aug. 24, to Sat., Sept. 8, at Toronto. A stand illustrating the United Kingdom's post-war scientific and technical achievements is being arranged by the British Government. Examples of automation equipment will be included in this display. Apply to the Board of Trade, Horse Guards-avenue, London, S.W.1.

***British Food Fair.**—Tues., Aug. 28, to Sat., Sept. 15, at Olympia, London, W.14. Including exhibition of food preparing and wrapping machinery. Organised by the British Food Fair, 290 Minster House, St. James'-court, London, S.W.1. Tel. VICtoria 3674.

International Society of Soil Science, Sixth International Congress.—Wed., Aug. 29, to Sat., Sept. 8, in Paris. Organised by the International Society of Soil Science, Royal Tropical Institute, 63 Mauritskade, Amsterdam, Holland.

British Association Meeting.—Wed., Aug. 29, to Wed., Sept. 5, in Sheffield. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109.

***Pretoria Industrial Exhibition.**—Fri., Aug. 31, to Sat., Sept. 8. Organised by the North Transvaal Chamber of Industries, P.O. Box 933, Pretoria.

Foundry Trades Fair, International (GIFA).—Sat., Sept. 1, to Sun., Sept. 9, at the Fair Halls, Düsseldorf. To be held in connection with the 23rd International Foundry Congress. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576. See ENGINEERING, October 21, 1955, page 565.

Strasbourg European Fair, 31st.—Sat., Sept. 1, to Sun., Sept. 16, at Strasbourg. *Agent:* R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

St. Erik's Fair.—Sat., Sept. 1, to Sun., Sept. 16, at Stockholm. *Agents:* Thirza West Publicity Ltd., 141 New Bond-street, London, W.1. Tel. MAYfair 3701.

***Damascus International Fair.**—Sat., Sept. 1, to Sun., Sept. 30, in Damascus. Including United Kingdom pavilion. Apply to British Overseas Fairs Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711.

Leipzig International Autumn Fair.—Sun., Sept. 2, to Sun., Sept. 9, Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Frankfurt International Autumn Fair.—Sun., Sept. 2, to Thurs., Sept. 6, at Frankfurt. *Agents:* Lep Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***British Mathematical Colloquium, Eighth.**—Tues., Sept. 4, to Thurs., Sept. 6, at St. Andrews. Apply to Mr. D. Borwein, Department of Mathematics, St. Salvator's College, St. Andrews, Scotland.

***Handicrafts, Homecrafts and Hobbies Exhibition.**—Thurs., Sept. 6, to Fri., Sept. 21, at Olympia, London, W.14. Apply to the exhibition organiser, 24 Store-street, London, W.C.1. Tel MUSeum 9792.

Electron Transport in Metals, Symposium on.—Mon., Sept. 10, to Fri., Sept. 14, at Ottawa, Canada. Apply to Professor P. Fleury, International Union of Pure and Applied Physics, 3 Boulevard Pasteur, Paris 15e.

Fatigue of Metals Conference.—Mon., Sept. 10, to Fri., Sept. 14, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

Utrecht International Autumn Fair.—Tues., Sept. 11, to Thurs., Sept. 20, at Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

Building Plant Exhibition.—Wed., Sept. 12, to Wed., Sept. 19, at the D and E Car Parks, Gosforth Park Racecourse, Great North-road, Newcastle-upon-Tyne. Organised by the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611.

***Sussex Industries Exhibition and Trade Fair.**—Wed., Sept. 12, to Sat., Sept. 22, at the Corn Exchange, Brighton. Organised by the Federation of Sussex Industries Ltd., 32 Duke-street, Brighton 1. Tel. Brighton 26189.

Static Electricity in Textiles, Overseas Conference on.—Thurs., Sept. 13, to Mon., Sept. 17, at Zürich. Apply to the general secretary, Textile Institute, 10 Blackfriars-street, Manchester 3.

Marseilles International Fair.—Sat., Sept. 15, to Mon., Oct. 1, at Marseilles. *Agents:* Butlers Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 5905.

American Society for Testing Materials.—*Pacific Coast National Meeting:* Sun., Sept. 16, to Sat., Sept. 22, at the Hotel Statler, Los Angeles, Calif. Offices of the Society: 1916 Race-street, Philadelphia 3, Pa., U.S.A.

***Functions and Education of Welding Engineers, Conference on.**—Mon. and Tues., Sept. 17 and 18, at Ashorne Hill, Leamington Spa. Organised by the Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. Tel. SLOane 9851.

***Instrument Automation Conference and Exhibit.**—Mon., Sept. 17, to Fri., Sept. 21, in the Coliseum, New York. Organised by the Instrument Society of America, 250 West 57th-street, New York.

British Road Federation's International Conference.—Mon., Sept. 17, to Thurs., Sept. 20, at Friends House, Euston-road, London, N.W.1. Theme: "Urban Motorways." Organised by the British Road Federation, 26 Manchester-square, London, W.1. Tel. WELbeck 0221.

Association of Public Lighting Engineers, Annual Conference.—Tues., Sept. 18, to Fri., Sept. 21, at Winter Gardens, Blackpool. Exhibition of Street Lighting Apparatus and Equipment at Winter Gardens, and Outdoor Display of Lamp Columns and Mobile Equipment in the Middle Walk Promenade. Organised by the Association of Public Lighting Engi... 17 Victoria-street, London, S.W.1. Tel. ABBey 4281.

Plastic Theory of Structures, Symposium on.—Tues., Se... to Fri., Sept. 21, at Clare College, Cambridge. Organ... the Department of Engineering, University of Cam... Engineering Laboratory, Trumpington-street, Cam... Tel. Cambridge 55691.

Physical Chemistry of Processes at High Pressures, Conferen... Thurs. and Fri., Sept. 20 and 21, at Glasgow. Apply to th... secretary, Faraday Society, 6 Gray's Inn-square, Londo... W.C.1. Tel. CHAncery 8101.

Commercial Motor Transport Exhibition, International.—... Sept. 21, to Sat., Sept. 29, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Trade... Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Science of Photography, International Conference on.—Mon., Sept. 24, to Thurs., Sept. 27, at Cologne. Apply to Dr. Walter Schürmeyer, Deutsche Gesellschaft für Photographie e.v., Hohenstaufenring 48/54, Cologne, Germany.

***Association of Iron and Steel Engineers, Convention and Exhibition.**—Tues., Sept. 25, to Fri., Sept. 28, at Cleveland. Apply to the exhibition manager, Association of Iron and Steel Engineers, Empire Building, Pittsburg 22, Pa., U.S.A.

Brussels Colonial Exhibition.—Sat., Sept. 29, to Sun., Oct. 14, in Brussels. Apply to Foire Coloniale de Bruxelles, 20-21 Boulevard Baudouin, Brussels.

Agricultural Engineering Exhibition, Eighth International.—Sat., Sept. 29, to Sun., Oct. 14, at Turin. Part of the Sixth International Technical Exhibition in this city. Apply to the exhibitions secretary, Via Massena, Turin.

Metz International Fair.—Sat., Sept. 29, to Mon., Oct. 15, at Metz. *Agents:* Auger and Turner Group, Ltd., Autur House, 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

***National Hardware Show.**—Mon., Oct. 1, to Fri., Oct. 5, in the Coliseum, New York. Organised by the National Hardware Show, Inc., 331 Madison-avenue, New York.

Fuel Efficiency Exhibition.—Tues., Oct. 2, to Wed., Oct. 10, at Olympia, London, W.14. Organised by Provincial Exhibitions Ltd., in association with F. W. Bridges and Sons, Ltd. Apply to the public relations officer, 9 Southampton-place, London, W.C.1. Tel. CHAncery 2131.

***Standards Engineers Society, Fifth Annual Meeting.**—Wed., Oct. 3, to Fri., Oct. 5, at the Hotel Willard, Washington, D.C. Theme: "Standards: Guides for To-morrow." Apply to the Society, P.O. Box 281, Camden 1, N.J., U.S.A.

***Cattle and Agricultural Machinery Exhibition, National.**—Sat., Oct. 6, to Sat. Oct. 13, at the Quinta Normal, Santiago. Organised by the Sociedad Nacional de Agricultura, Tenderini 187, Santiago, Chile.

***Metal Exposition, 38th National.**—Mon., Oct. 8, to Fri., Oct. 12, at Cleveland, Ohio. Organised by the Metal Show Department, American Society for Metals, Cleveland 3, Ohio.

***Firato Radio and Television Exhibition.**—Mon., Oct. 8, to Mon., Oct. 15, in the R.A.I. Building, Amsterdam. Apply to Mr. H. J. Kazemier, Emmalaan 20, Amsterdam-Z.

"Vochema" International Fair.—Tues., Oct. 9, to Wed., Oct. 17, at Utrecht. Comprises machinery and equipment for the food industry, and the chemical and pharmaceutical industry. *Agent:* W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

***Tunis International Trade Fair, Fourth.**—Sat., Oct. 13, to Sun., Oct. 28. Organised by the Foire Internationale de Tunis, Palais Consulaire, Avenue Roustan, Tunis.

***Sanitation Maintenance Show.**—Sun., Oct. 14, to Tues., Oct. 16, in the Coliseum, New York. Including capital goods, and machinery. Organised by Orkin Expositions Management, 19 West 44th-street, New York.

Motor Show (41st International Motor Exhibition).—Wed., Oct. 17, to Sat., Oct. 27, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Application of Low Alloy Steels for Welded Pressure Vessels, Symposium on.—Fri., Oct. 19, at 39 Elmbank-crescent, Glasgow, C.2. All-day conference, organised by the West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. Tel. Central 5181.

***Production Engineering Show.**—Mon., Oct. 22, to Thurs., Oct. 25, in the Convention Hall, Philadelphia. Organised by Clapp and Poliak, Inc., 341 Madison-avenue, New York 17.

Dairy Equipment Exhibition.—Sat., Nov. 3, to Mon., Nov. 12, in Paris. Apply to the Commissaire-General, Salon International de l'Equipement Laitier, 28 Rue Louis-le-Grand, Paris, 2e.

***Arizona State Fair.**—Sat., Nov. 3, to Mon., Nov. 12, at Phoenix, Arizona, U.S.A. United Kingdom exhibit. Information from British Consulate General, 448 South Hill-street, Los Angeles 13, Cal., U.S.A.

***Canadian National Packaging Exposition.**—Tues., Nov. 6, to Thurs., Nov. 8, at Toronto. Organised by the Packaging Association of Canada, 916 Yonge-street, Toronto 5, Canada.

***Royal Agricultural Winter Fair.**—Fri., Nov. 9, to Sat., Nov. 17, at Toronto. Apply to Royal Winter Fair, Exhibition Park, Toronto 2B, Canada.

***Cycle and Motor Cycle Show, 31st International.**—Sat., Nov. 10, to Sat., Nov. 17, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Industries Association, Ltd., The Towers, Warwick-road, Coventry (Tel. Coventry 62511); and 20-23 Lincoln's Inn Fields, London, W.C.2. Tel. CHAncery 4152. (Alteration of name of organisers.)

Public Works and Municipal Services Congress and Exhibition.—Mon., Nov. 12, to Sat., Nov. 17, at Olympia, London, W.14. Organised by the Municipal Agency, Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132.

***Calder Works Nuclear Power Plant, Symposium on.**—Thurs., and Fri., Nov. 22 and 23, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Organised by the British Nuclear Energy Conference, 1-7 Great George-street, London, S.W.1. Tel. WHItehall 4577.

***Power and Mechanical Engineering, 22nd National Exposition.**—Mon., Nov. 26, to Fri., Nov. 30, at the Coliseum, Columbus Circle, New York. Held under auspices of American Society of Mechanical Engineers, 29 West 39th-street, New York 18. *Managers:* International Exposition Co., 480 Lexington-avenue, New York 17.

***Automation Exposition, Third International.**—Mon., Nov. 26, to Fri., Nov. 30, at 500 Eighth-avenue, New York. Organised by Richard Rimback Associates, 845 Ridge-avenue, Pittsburg 12, Pa., U.S.A. *Agents:* T. G. Scott and Sons, Ltd., 243/247 Regent-street, London, W.1. Tel. REGent 3891.

***Chemical Exhibition, National.**—Tues., Nov. 27, ... Fri., Nov. 30, at Cleveland, Ohio. Organised by the American Chemical Society, 86 E. Randolph-street, Chicago ... Ill., U.S.A.

Smithfield Show and Agricultural Machinery Exh... on.—Mon., Dec. 3, to Fri., Dec. 7, at Earl's Court, Lon... W.5. Apply to the exhibition manager, Smithfield ... Joint Committee, 148 Piccadilly, London, W.1. Tel. G... enor 4040.

In Parliament

CIVIL USES OF ATOMIC ENERGY

Agreement between Great Britain and the United States on the civil uses of atomic energy was announced in the House of Commons last week, when the Secretary of State for Foreign Affairs, Mr. Selwyn Lloyd, informed Mr. A. Henderson (Labour) that the text of the document giving effect to it would be published as a White Paper immediately (Cmd. 9789, H.M.S.O., price 4*d.* net). Mr. Lloyd said that this agreement was one of the results of the closer co-operation between this country and the United States foreshadowed in the communiqué issued last February after the discussions which he and Sir Anthony Eden had had with President Eisenhower and Mr. Dulles.

In effect, the new agreement was an amendment to the agreement signed last year between the United States and the United Kingdom for co-operation on the civil uses of atomic energy, and it would extend that agreement to make provision for a broader exchange of materials used in the atomic energy programmes of the two countries. It would also provide for the exchange of information concerning military package-power reactors and other military reactors for the propulsion of naval vessels, aircraft and land vehicles. The new agreement would not come into force, however, until the appropriate formal documents had been exchanged between the two countries. Mr. Lloyd agreed with Mr. Henderson that the exchange of information on test nuclear explosions was not covered by the new agreement.

RAILWAY ELECTRIFICATION VOLTAGE

In reply to Mr. Geoffrey Wilson (Conservative), who inquired as to the system of railway electrification to be adopted by the British Transport Commission, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, said that he had now completed his consultations with other Ministers on this subject. He had accordingly informed the Commission of his approval to their proposals for the adoption of the 50-cycle alternating-current system, with overhead supply, as a general standard for the future electrification of British Railways.

There would be an exception to this arrangement in the case of the electrification which was being undertaken on certain sections of the Southern Region of British Railways. Circumstances there required that the low-voltage direct-current third-rail system of electrification should be retained.

HUNTER-PERCIVAL HELICOPTER

Mr. Reginald Maudling, the Minister of Supply, informed Captain H. B. Kerby (Conservative) that the Hunter-Percival research helicopter, for which a contract had been placed by his Department in 1951, had not yet flown. Ground-running trials had commenced on April 29, but were not yet complete. Mr. Maudling said that, as announced by him in the defence debate on February 29, it had been decided, as part of the rationalisation of the helicopter programme, to discontinue the Government's support of this project, but a limited amount of ground running and flight testing would be carried out before work ceased.

Government Use of Unpatented Inventions

The report of the committee of inquiry into the use of unpatented inventions for defence production, presided over by Sir Harold Howitt, G.B.E., F.C.A., was published on June 20 (*Defence Contracts, Report of the Committee of Enquiry*, Cmd. 9788, H.M.S.O., price 1*s.*, net.). When reporting this to the House, Mr. Peter Thorneycroft, the President of the Board of Trade, said that the committee recommended that the Crown should be given permanent powers to authorise the use of unpatented inventions and unregistered designs in connection with defence and Civil Defence contracts, subject to strict provisions which the committee had worked out to give proper safeguards to industrial interests.

After careful consideration, the Government had decided to accept the committee's main recommendations, with one modification. The committee had recommended that the taking of certain decisions should be confined, by legislation, to the appropriate Minister or the permanent head of his Department. Instead of this, administrative steps would be taken to ensure that these decisions were taken by Ministers or senior officials only. Mr. Thorneycroft told Mr. Peter Kirk (Conservative) that he proposed to discuss the recommendations in detail with industrial organisations, and to introduce legislation to give effect to them as soon as practicable. This legislation would enable the emergency powers under which Government Departments had been operating to be revoked.

Long Term Investment in Coal Industry

Attention was drawn by Mr. A. M. F. Palmer (Labour) to the recent report prepared by the experts of the Organisation for European Economic Co-operation urging that long-term investment in the coal industries of the member countries, including the United Kingdom, should be well maintained. He pointed out to the Minister of Fuel and Power, Mr. Aubrey Jones, that this report also emphasised the dangers of the popular misconception that nuclear energy would largely replace coal as a source of energy in the near future. Mr. Jones replied that the report was a most valuable one. It demonstrated convincingly the essential part that coal must continue to play in the economic life of Western Europe for many years to come, and confirmed the need for further investment in the British coal industry.

Oil for Coal

The problem of how to increase Britain's total fuel resources was also brought to the fore. Mr. Aubrey Jones informed Mr. G. Nabarro (Conservative) that the total deliveries of black oils, apart from refineries' own consumption and the Diesel oil used for road vehicles, increased by no less than 1,200,000 tons, or 18 per cent., during the year ended March, 1956, as compared with the year ended March, 1955. The coal equivalent of the increase would be about two million tons, but, said Mr. Jones, he could not view the substitution of oil for coal with satisfaction, because it involved a net burden on the balance of payments position. The country's energy problem was not so simple as the substitution of one form of energy for another. In fact, the nation needed every description of fuel that it could lay its hands upon. To sustain Britain's industry and employment at a high level, large imports of oil were required as well as a speeding-up of conversion to oil.

Concessionary Coal Allocations

Captain H. B. Kerby (Conservative), asked the Minister of Fuel and Power whether he was aware that, if the free concessionary coal, or coal at nominal prices, provided by the National Coal Board for miners, typists and other employees, were reduced to the amounts of other domestic consumers' allowances, another four million tons of coal a year would become available. Further, Captain Kerby pointed out, the saving on importing this quantity of coal from overseas would amount to some £23 million a year. Mr. Aubrey Jones replied that concessionary coal was traditionally a part of the remuneration of workers in mining industry. For the most part, the practice was governed by long-standing individual colliery agreements concluded between employers and workpeople. Any change in those agreements must be negotiated between the parties concerned.

Government Scientific Organisation

In his capacity of representative in the House of Commons of the Lord President of the Council, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Works, had his attention called to the need for publishing a revised issue of the memorandum relating to Government scientific organisation in the civilian field. This publication, which is prepared by the Advisory Council for Scientific Policy, was last issued by Her Majesty's Stationery Office in July, 1951, and Sir Hugh Linstead (Conservative) pointed out that numerous changes have been made in the Government's organisation in this respect during the intervening period. Mr. Bevins said that publication of this information would be considered at a suitable opportunity.

High Energy Physics Symposium

Mr. Bevins informed Sir James Hutchison, Bt. (Conservative) that the *Proceedings* of the meeting of the European Organisation for Nuclear Research on "High Energy Physics" would be published in due course, but that, owing to the work involved, it was unlikely that copies would be available until the end of the year.

Steel Shortages in Sunderland

Mr. F. T. Willey (Labour) inquired what requests had recently been made to the Admiralty for assistance by Sunderland shipbuilding firms which were experiencing difficulty in obtaining supplies of steel. In reply, Mr. S. Wingfield Digby, Civil Lord of the Admiralty, said that there had been one such request so far this year. The matter had been taken up with the British Iron and Steel Federation, but, because the firm concerned expected to receive more steel in 1956 than in either 1955 or 1954, the Federation could not promise further assistance until the needs of firms still receiving less had been met.

Technical State Scholarships

Mr. Malcolm MacPherson (Labour) asked the Minister of Education about the numbers of adequately qualified applicants for technical State scholarships during recent years. In reply, Sir David Eccles said that the numbers of candidates who satisfied the minimum conditions of entry to the competition were 454 in 1951; 351 in 1952; 429 in 1953; 426 in 1954; and 456 last year.

Atmospheric Sulphur Compounds

As a representative in the House of Commons of the Lord President of the Council, Mr. R. H. Turton, the Minister of Health, was asked if he would instruct the Medical Research Council to undertake research into the possibility of manufacturing an automatic continuous-recording machine for giving both the total sulphur content and the amount of sulphur trioxide in the atmosphere. Mr. Turton told Dr. Barnett Stross (Labour), who raised the matter, that such research was probably rather a matter for the Department of Scientific and Industrial Research, and that the Atmospheric Pollution Research Committee of the Fuel Research Association was examining the problem of the continuous recording of sulphur compounds in the atmosphere.

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NOTICES OF MEETINGS

British Productivity Council

LONDON
All-Day Discussion on "Productivity and the Production Worker." Organised by the North London Productivity Committee. Tottenham Central Library, 391 High-road, London, N.17. Thursday, July 5, 10 a.m. to 5.30 p.m. (Registration fee 5*s.*)

Manchester Joint Research Council

MANCHESTER
Address on "Automation," by the Earl of Halsbury. Whitworth Hall, The University, Manchester. Mon., July 9, 2.15 p.m. (Admission by ticket.)

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

British Productivity Council. Apply to Mr. Charles Cooper, 126 The Ridgeway, Enfield. (HOWard 2611.)
Manchester Joint Research Council, Chamber of Commerce, Ship Canal House, King-street, Manchester 2. (Deansgate 5574.)

THE HUMAN ELEMENT

Imagination alone can solve skill-differential problems in the steel industry—Redundancy may subside in Coventry area—Civil Service pay approaches market rate—Employers contribute more to superannuation funds than employees—In spite of increases, teachers' pay still lags behind industrial scales.

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Wage Differentials in Steel

A futile impasse has now been reached in the overtime ban among maintenance craftsmen in the steel industry. Efforts to find a way out last Friday both at formal meetings and informal ones went unrewarded. It is important that both sides should realise that they are standing on formulae which have led nowhere in similar circumstances in other industries recently, and that there is need for some fresh original thinking.

The men are striking for the preservation of craft differentials in connection with a recent pay increase award. The employers have said that they will negotiate once the men return to work. Both sides are acutely aware that a better offer to the maintenance men may mean a quick counter-demand from the unskilled workers and the vicious spiral will be off again. The steel industry has an enviable reputation in industrial relations. It might have been hoped that against this background, those concerned would have grasped this nettle of skilled differentials. That it will have to be grasped is apparent to all concerned with management-labour relations and there is no better place to do so than in an industry with a long reputation of good sense in these matters.

It has been estimated that the ban (it is a strike in certain areas where stabb is being used to do maintenance work) is costing more than 200,000 tons of steel. It is costing lost leadership opportunities as well.

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No Strike at Coventry—Yet

As the painful story of the redundancy at the Standard Motor Company's tractor works unfolds itself, it is becoming evident that no one quite knows how to tackle the problem. There were two meetings last week, one between the workers' representatives and the company's management and one between the representatives of the nine unions involved in the dispute. At the first meeting the company made two proposals—to give the 2,640 workers already dismissed or under notice the first options on jobs becoming available as tractor production builds up in the autumn, or to investigate further the possibility of absorbing more workers at the Canley car plant. They turned down a proposal to extend the rota shift system put forward by the shop stewards. At the unions' meeting, the main decisions were that there would be no immediate official strike and that those in attendance should meet the company's shop stewards at Coventry. The unions still felt that Standard could introduce a shorter working week in both plants and lay off men on a rota one week in five, with a guaranteed payment of £6 in the lay-off period. They agreed, however, that a refusal to admit any redundancy was impracticable.

The unions' representatives are now to see for themselves how much short-time the car workers are willing to work to absorb tractor men. Also, whether all of the 11,000 of the company's workers are ready to strike if the management refuse to compromise. They may well find that the resolve to fight at all cost has weakened. Only 700 of the first 1,325 workers to be dismissed sought the assistance of the Labour Exchange, of whom 300 were offered other jobs. Unemployment and short-time working are decreasing in the area, and it is conceivable that the Standard Motor Company themselves will be looking for men by the autumn.

But redundancy and the problems it brings in its wake in a country where there have been more jobs than workers almost continuously for 18 years remain formidable obstacles in the way of change. The problems are personal problems, of men and their families. The need for greater mobility of labour is real enough. Yet it is one thing to pass on from one job to a better-paid one and quite another to reverse the process.

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Civil Service Pay

At a meeting held towards the end of last week, the staff side of the Civil Service National Whitley Council ratified the agreement made with H.M. Treasury some time ago on pay, leave and hours. This affects about 380,000 civil servants. Agreement was reached early this year with representatives of the staff concerned, but the process of ratification had to be gone through by all organisations representing the staffs, and there has been the additional complication that the proposals had to be accepted or rejected as a whole.

Revised pay scales will come into effect backdated to April 1, and the five-day week comes into operation on July 1. Pay increases which have already been made on an interim basis are expected to cost the taxpayer £30 million a year.

With the formal ratification of the scheme comes a wide-scale move to put the level of civil service salaries somewhere nearer the market rate. In some ways, only a beginning has been made to this, especially on the technical side, but at least the policy of adhering to something near the market rate has now been enshrined in formal staff agreements. Not the least interesting change in the terms of work for civil servants of staff grades is the abolition of overtime. This is particularly significant in timing when pressure is building up both through deflation and social thinking to reduce the burden of overtime on the economy as a whole.

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Superannuation Funds

There is an increasing tendency for employers to contribute more to superannuation schemes than employees. This fact is not surprising in an age when there is a premium on technical men. The statement, however, has statistical backing in a survey recently undertaken among its members by the Association of Superannuation and Pension Funds.

In May, 1954, the Association issued a questionnaire to its ordinary members asking in confidence for certain information about schemes. Over 80 per cent. replied. According to the returns, the employer contributed more than the employee in 59 per cent. of the cases and he contributed equally in 21 per cent. of cases. If the number of new funds since 1945 is taken alone, however, the percentage where the employer contributed most increases to 66.

Another group of questions of interest concerned the basis of calculation. The 80 per cent. or so replying covered 902 schemes and about 1,482,000 staff. Retirement benefits were calculated on the basis of salary through service in 35 per cent. of cases of privately administered funds and 22 per cent. in the case of those operated by life offices. Twenty-nine per cent. of those privately administered were based on the last five years' salary and 6 per cent. on the last three years' service. It was noticeable that on a counting of heads, a large number of schemes are quite small. Nearly 50 per cent. of privately administered schemes were for up to 500 members, and only 3 per cent. for those with over 15,000.

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New Salary Scales for Teachers

All-round increases to the salaries of teachers in technical colleges and institutes, art colleges and schools in England and Wales have been recommended by the Burnham Technical Committee. The increases range from £25 a year for the most junior grade of teaching assistant to £385 a year for the most senior head of department. But even then the salaries do not compare at all favourably with those paid to equivalent men and women in industry. Nor is there any suggestion of equal pay.

The head of a department in a college of advanced technology who is in grade VI (the highest grade) will receive £2,250 a year if a man, £1,800 a year if a woman. A senior lecturer's salary would range from £1,350 a year to £1,550. Such salaries, for highly qualified teachers who are the keystone of this country's efforts to remain a leading industrial nation, are quite inadequate.

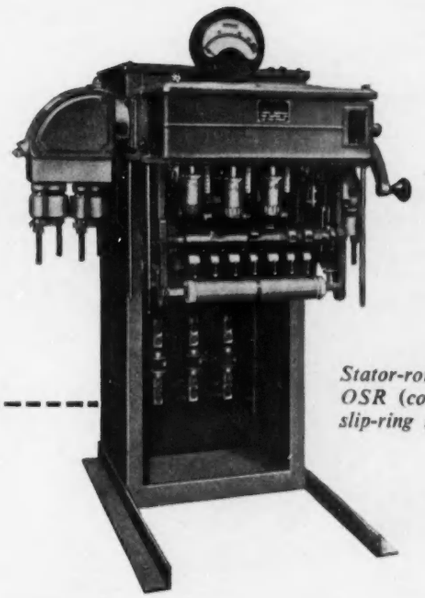
Teachers' pay has long been a subject of fierce controversy. There is a shortage of good men and women in far too many schools, particularly for the teaching of mathematics and the sciences. In the early "teens" or even before, a pupil can be completely lost to technology through bad teaching. This means that much more attention should be paid to recruiting a good standard of teacher from the universities. At the present rate of pay, however, or even at the new recommended scales, there is little incentive to a technical man to enter the teaching profession, even if he feels attracted by such a career. It will hardly be to the country's benefit, or for that matter to industry's if this is allowed to persist. More and better teachers would go far to solve the problem of too few able technologists.

THE END OF THE 181st VOLUME

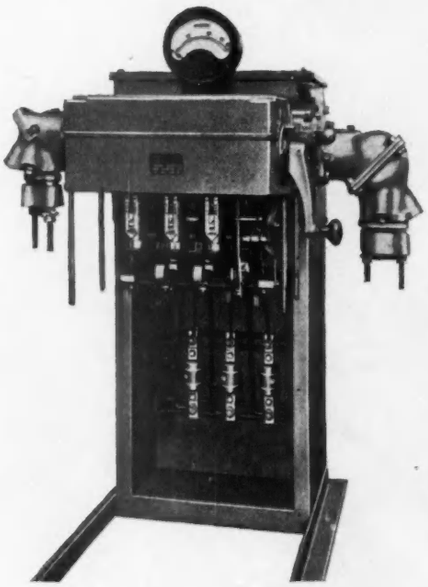
METROVICK OIL-BREAK STARTERS

Metrovick hand-operated oil-break starters, Type O, are available in a wide range — for direct-on, star-delta and auto-transformer starting of squirrel-cage motors, and stator-rotor starting of slip-ring motors.

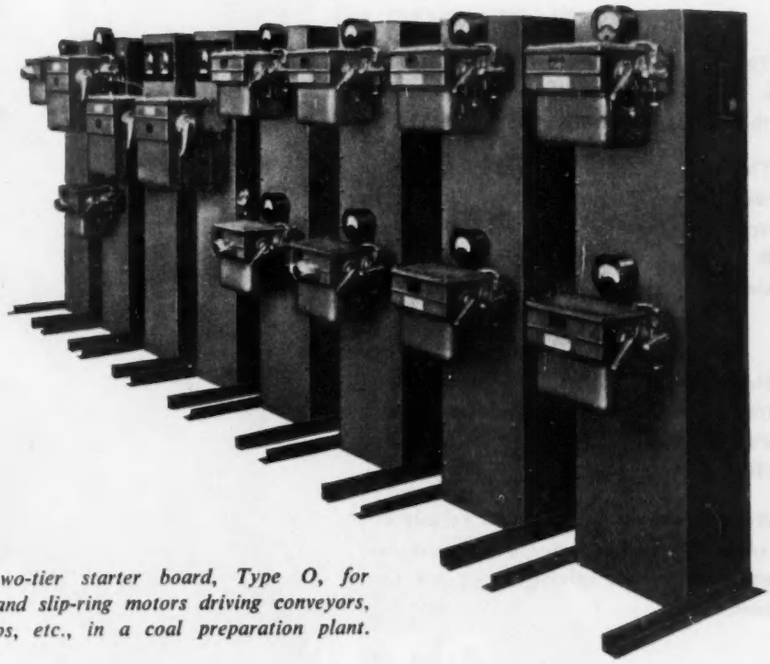
Please write for leaflets giving further details.



Stator-rotor, starter, Type OSR (covers removed) for slip-ring motors.



Direct-on starter, Type OD (covers removed) for squirrel-cage motors.



Multi-panel two-tier starter board, Type O, for squirrel-cage and slip-ring motors driving conveyors, screens, pumps, etc., in a coal preparation plant.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

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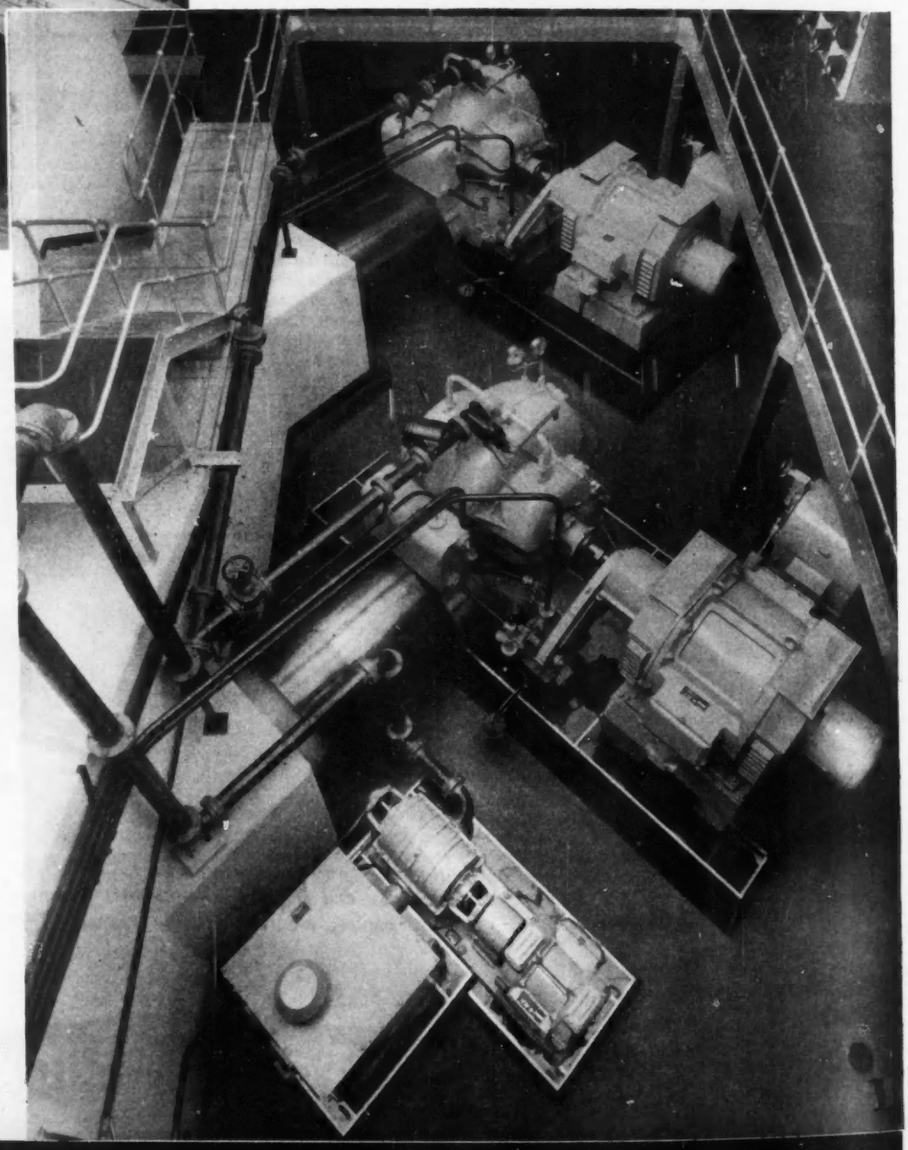
AND HIGH SPEED STEAM ENGINES *for* LAND & MARINE SERVICES



The illustrations show the new No. 8 Dry Dock and Pumphouse recently opened at North Shields for Smith's Dock Co. Ltd.

The Main Dock De-Watering Pumps consist of Two Drysdale 42in. Electrically Driven Centrifugal Pumps, each delivering 37,000 G.P.M. and incorporating our patent valveless Anti-Syphon System.

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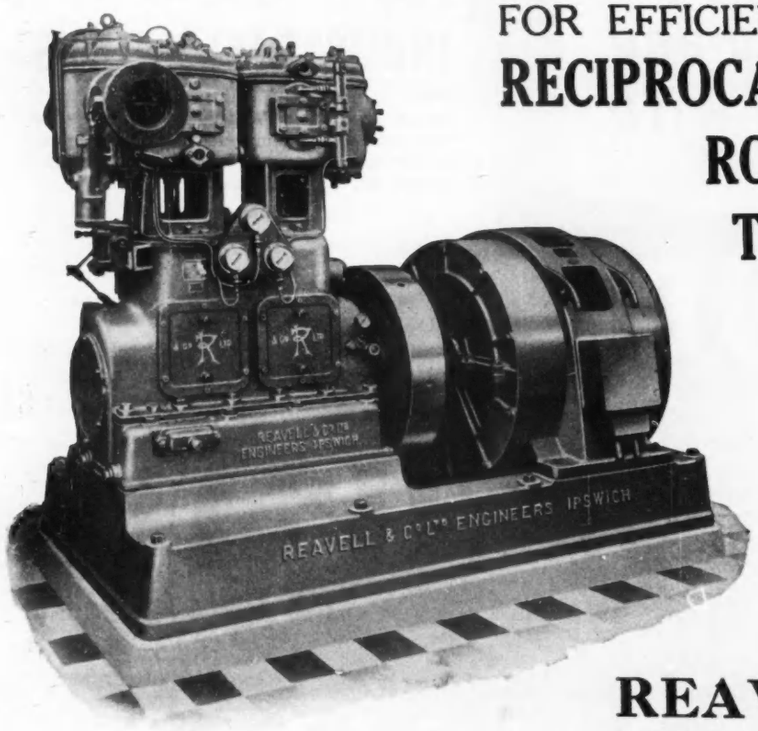

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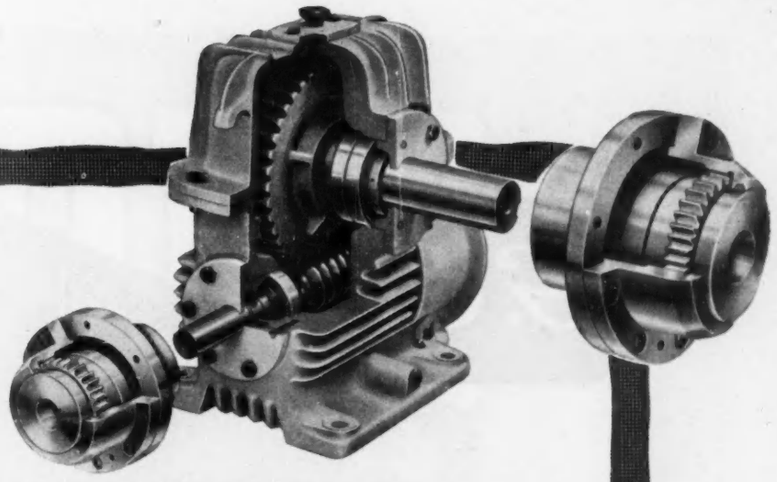

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Outstanding features of the standard Worm Gear unit include—
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By incorporating a graduating valve and a number of "on-off" valves in one unit, control of a whole system can be achieved. Such a unit provides complete control of the engines and transmission of a ship direct from the bridge without needing a second person to effect the required changes. When individual control of several engines is required, an appropriate number of control valves is employed. Westinghouse units can be used to control a variety of operations, covering—

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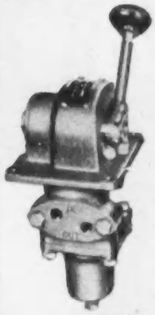

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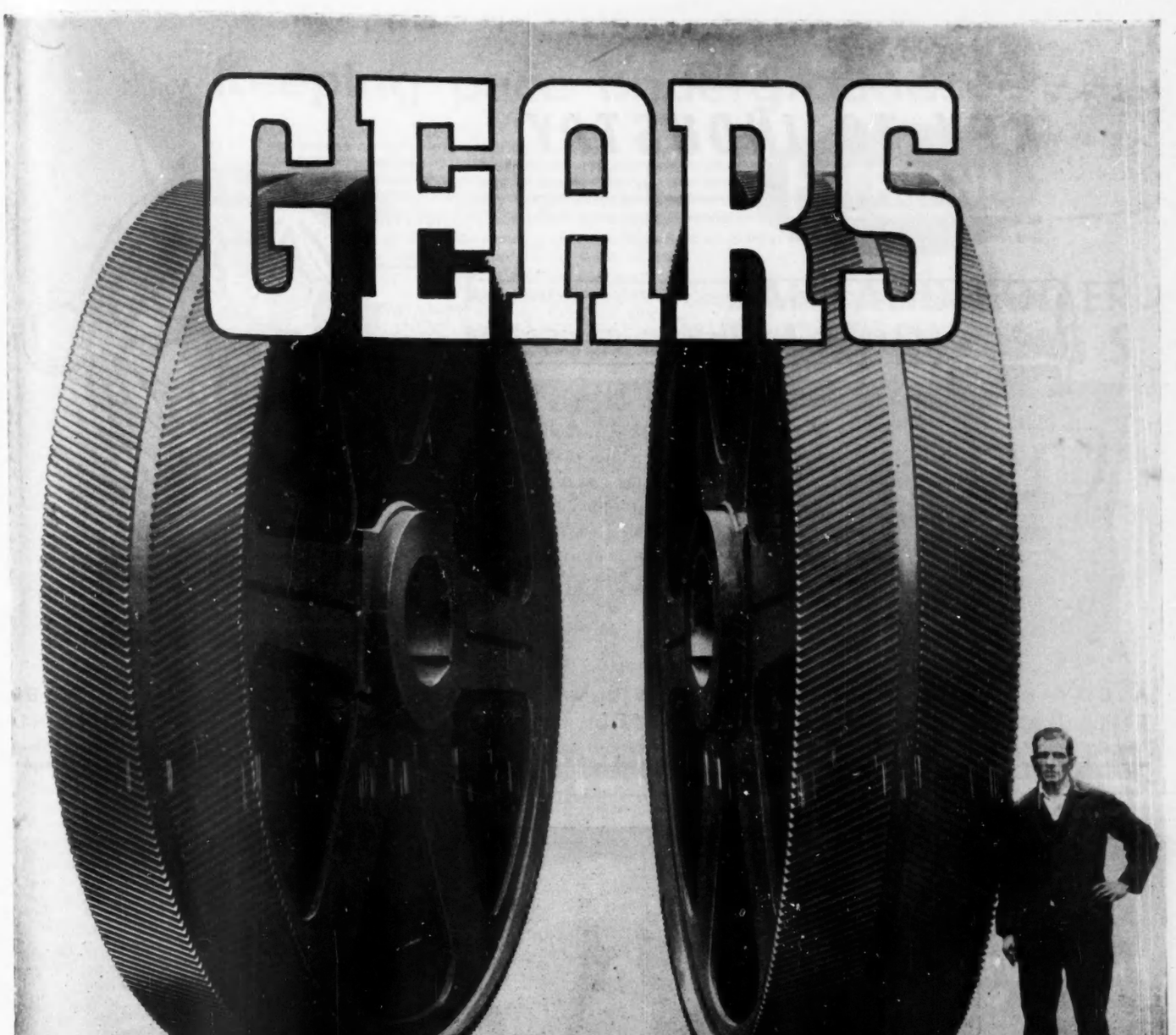

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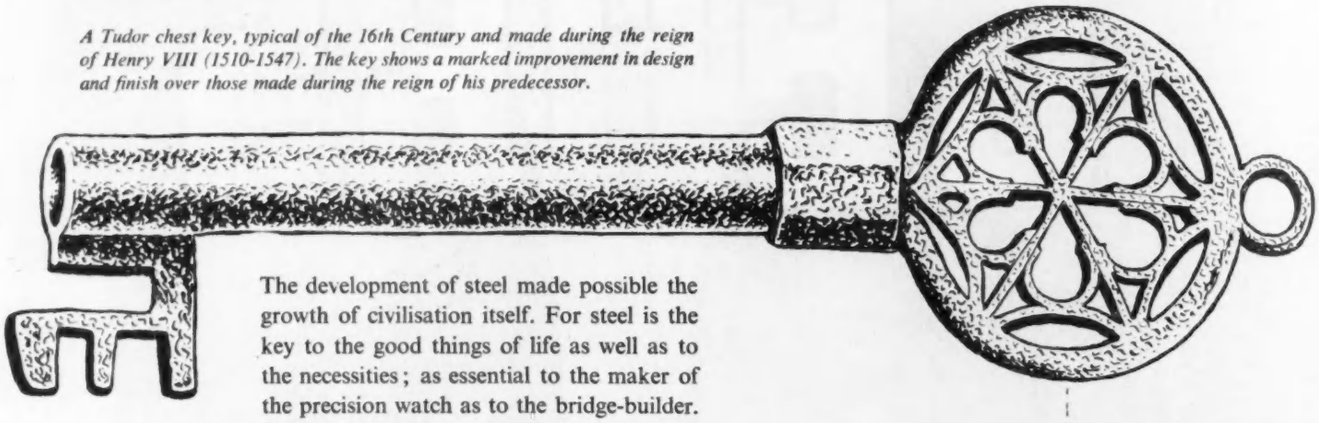
STEEL
KEY TO INDUSTRY

No. 13

A Tudor chest key, typical of the 16th Century and made during the reign of Henry VIII (1510-1547). The key shows a marked improvement in design and finish over those made during the reign of his predecessor.



The development of steel made possible the growth of civilisation itself. For steel is the key to the good things of life as well as to the necessities; as essential to the maker of the precision watch as to the bridge-builder. Hallamshire high-grade Alloy and Carbon steels serve a multitude of industries in many ways.

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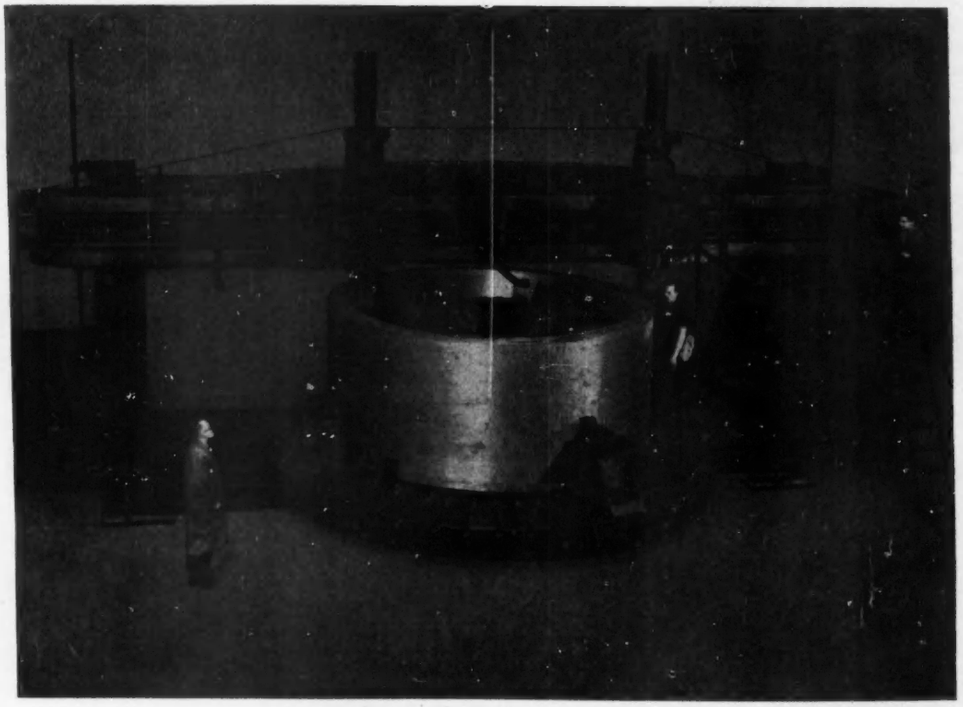
This Machine can Swing 23′ 0″ diar.



The Section of the Slab is 5′ 0″ × 10″

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BY
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presents no problem with this electric rotary drilling machine used for mining iron ore. Made to stand solidly when boring, it handles all loading weights and drill thrust without complications. 90% of the antifriction bearings are Hoffmann. They are fitted throughout in the travelling gearbox carrying the feed and retraction clutches together with the drill chuck.

HOFFMANN

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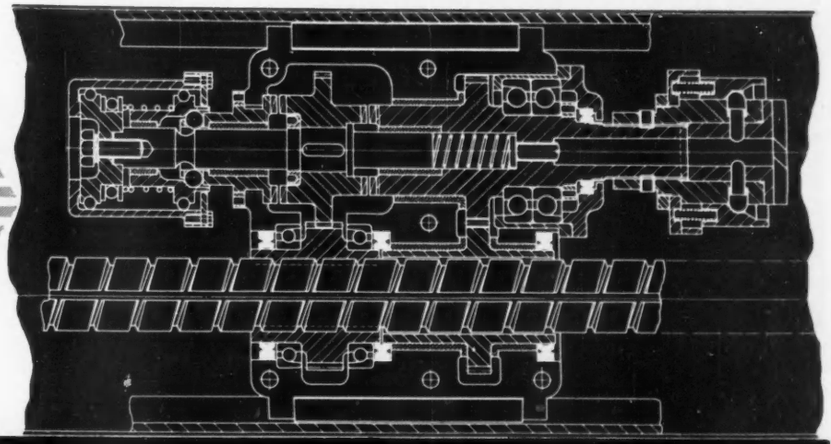
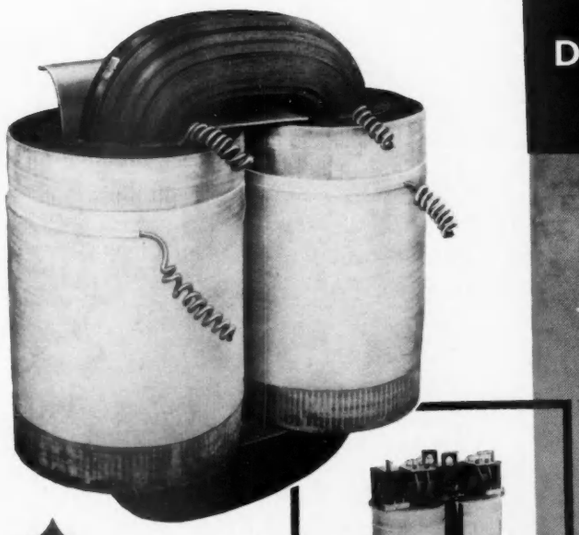


Designed by Mr. E. W. Hurd to the order of Messrs. United Steel Companies Limited, and manufactured by Messrs F. Taylor and Sons (Manchester) Ltd.

Line drawing illustrating travelling gearbox. Note the paired angular contact bearings used with their closed sides abutting and their open sides facing.

THE HOFFMANN MANUFACTURING CO. LTD. CHELMSFORD, ESSEX



This illustration shows clearly the Lock Wound Core construction.

Core and coil assembly of a 15 kVA, 11000/250 volt transformer.

NEW LOCK WOUND CORE POLE MOUNTING DISTRIBUTION TRANSFORMERS UP TO 25 kVA

Ferranti Ltd. introduce a rural distribution transformer incorporating a new core design. The core consists of strips of low loss grain oriented steel wound into a coil, the overlapping joints being locked in position. As the flux path follows the grain of the steel and air gaps in the core structure are almost eliminated, the design gives lower iron losses and reduced magnetising current.

Transformers of this type can be delivered from stock.

- LOWER IRON LOSSES
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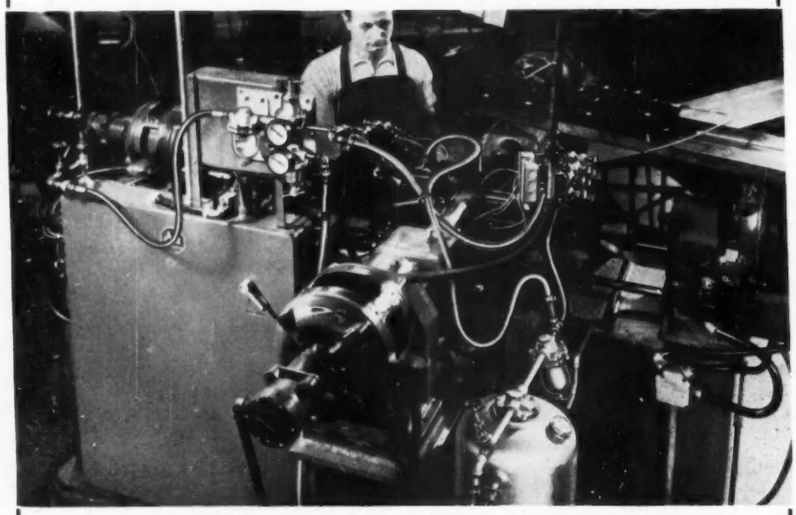

Illustrated is a special tapping machine equipped for the tapping of up to twelve holes of mixed sizes simultaneously. Trouble was experienced with flood cooling causing tap breakages, interruption of coolant supply by swarf and splashing. By changing to Norgren Spray-Lube, tap breakage was greatly reduced and, without splash, work space, machine and operator were kept clean.

Whether the operations are drilling, countersinking or tapping, Spray-lube gives longer tool life, better finish, and cleaner working conditions.

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MICRO-FOG LUBRICATOR

AN ENTIRELY NEW DESIGN FOR BETTER LUBRICATION OF BEARINGS, SPINDLES, GEARS, CHAINS ETC.

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The photograph on the right shows the completed job mounted ready for despatch by road. Total weight of the finished product was approximately 37 tons.

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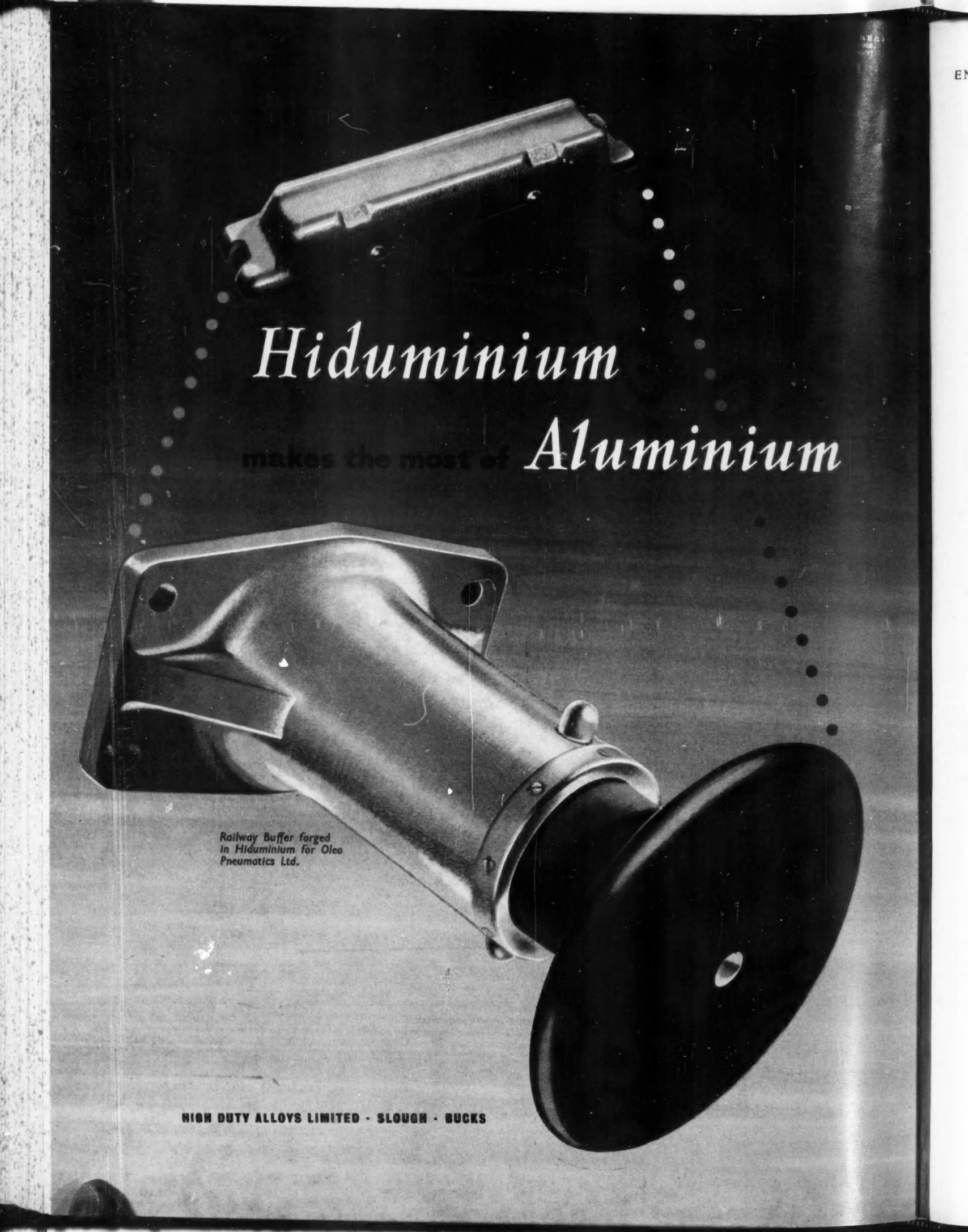
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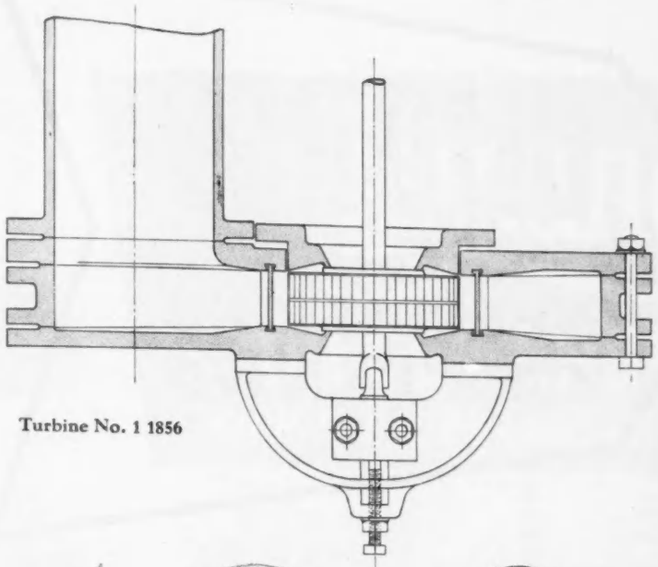

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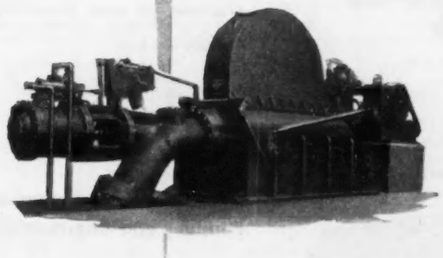
The drawing above shows our Water Turbine No. 1, manufactured in Kendal in 1856. It develops 5 horsepower and is still giving useful service. Since those early days, we have built over 5,400 turbines, and are the only firm in the United Kingdom which has been continuously building water turbines for a century. We have constructed water turbine governors since before 1900 and we were the first manufacturers to set up a permanent water turbine test plant in this country. Constant development work has kept us in the forefront of water turbine design; the "Gilkes" Turgo Impulse Wheel has a specific speed far higher than that of any other single jet impulse turbine; the "Giljet" Governing System gives unique regulation for Francis turbines with long pipelines. The 9,000 H.P. Pelton Wheel shown in the lower illustration is typical of our modern designs; it operates in the High Andes of Bolivia, utilising a head of 2,600 feet.



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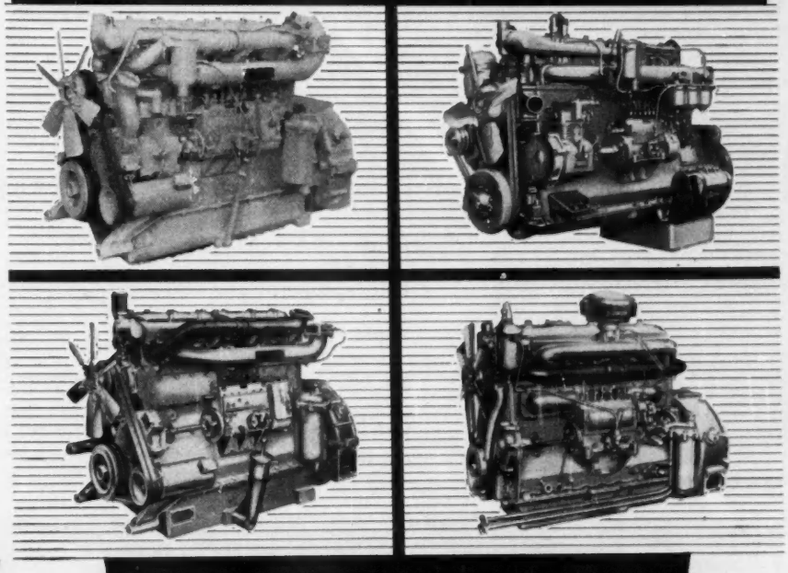

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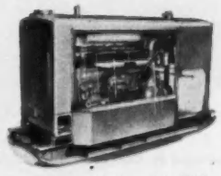

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600 Vertical or Horizontal	4.8 in. (121.92 mm.)	5.5 in. (139.7 mm.)	597 cu. in. (9.8 litres)	1,625 lb. (738 Kg.)	125 b.h.p. at 1,800 r.p.m.	112.5 b.h.p. at 1,800 r.p.m.	92 b.h.p. at 1,600 r.p.m.
680 Vertical or Horizontal	5 in. (127 mm.)	5.75 in. (146 mm.)	677 cu. in. (11.1 litres)	1,640 lb. (744.5 Kg.)	150 b.h.p. at 2,000 r.pm.	135 b.h.p. at 2,000 r.p.m.	115 b.h.p. at 1,800 r.p.m.
900 Vertical or Horizontal	5.5 in. (139.7 mm.	6.5 (165.1 mm.)	927 cu. in. (15.2 litres)	2,580 lb. (1170.2 Kg.)	200 b.h.p. at 1,840 r.p.m.	170 b.h.p. at 1,800 r.p.m.	142 b.h.p. at 1,600 r.p.m.

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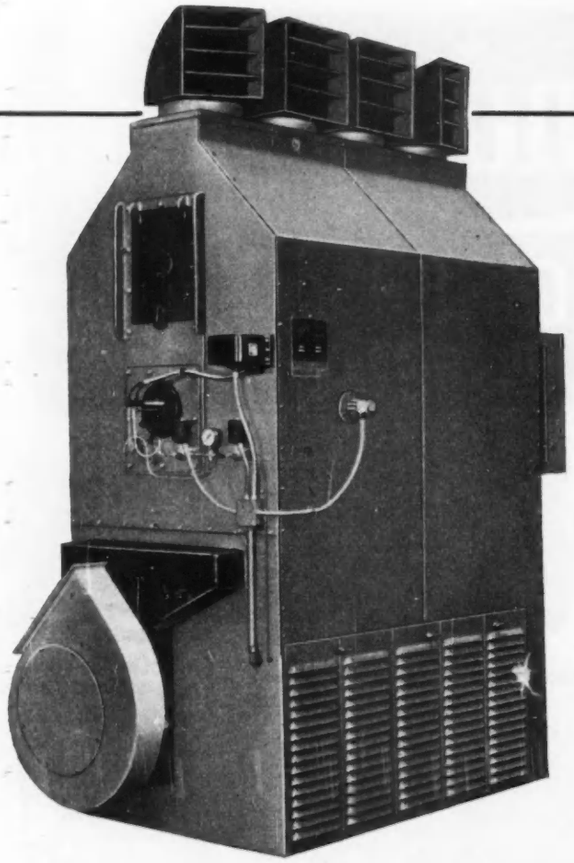

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THE DIRECT OIL-FIRED AIR HEATER FOR INDUSTRY

The modern method of heating is by warm air, particularly for large spaces such as in factories and other industrial premises. The DRAVO is a fully automatic warm air heater which is simple to install and offers exceptional economies in both capital cost and running costs. One unit can heat a shop of up to 30,000 square feet. The installations illustrated below are typical of many in which DRAVO heaters have successfully overcome the large space heating problem.

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Simple and economical installation.

Fully automatic and economical in running.

Rapid response, heat where you want it, when you want it.

No boiler house and no expensive mains.

Can be installed in the most convenient position—either on the floor, on the wall or on the roof trusses.

A heavy engineering shop

Supplying make-up heat in a foundry

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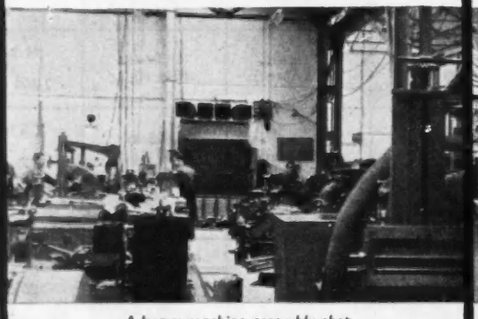
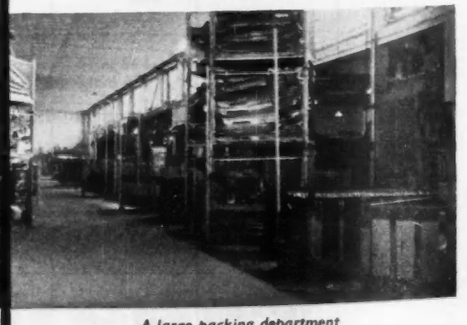


A heavy machine assembly shop



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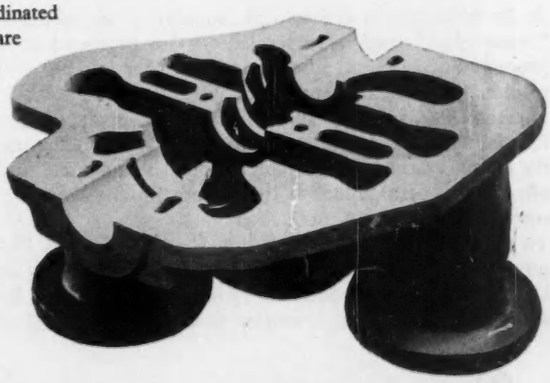
'Two birds with one stone'

OR—machine your components where they are cast

The proof of a casting lies in the machining. In this respect, Lloyds command an advantage over most steel foundries in that they have unique on-the-spot facilities for machining castings made in their own foundry. This service operates to the advantage of the customer.

When an order is placed with Lloyds for casting and machining, the two operations are co-ordinated and treated as one production job. Casting methods are prepared for jigging, important faces are given special care in the foundry and the finished product benefits by an integrated system of quality control.

This service is used continuously by the prime engineering concerns in this country. They also use Lloyds extensive capacity for proof machining or high precision finish machining. Lloyds machine shops represent the best in highly skilled personnel and modern equipment that the renowned Midlands can offer.



PUMP BODY, *weight 1,230 lbs., dimension 2' 11½" x 2' 8" x 1' 8½". Cast for Sigmund Pumps Ltd.*

A Print for Industry Ltd. advertisement.

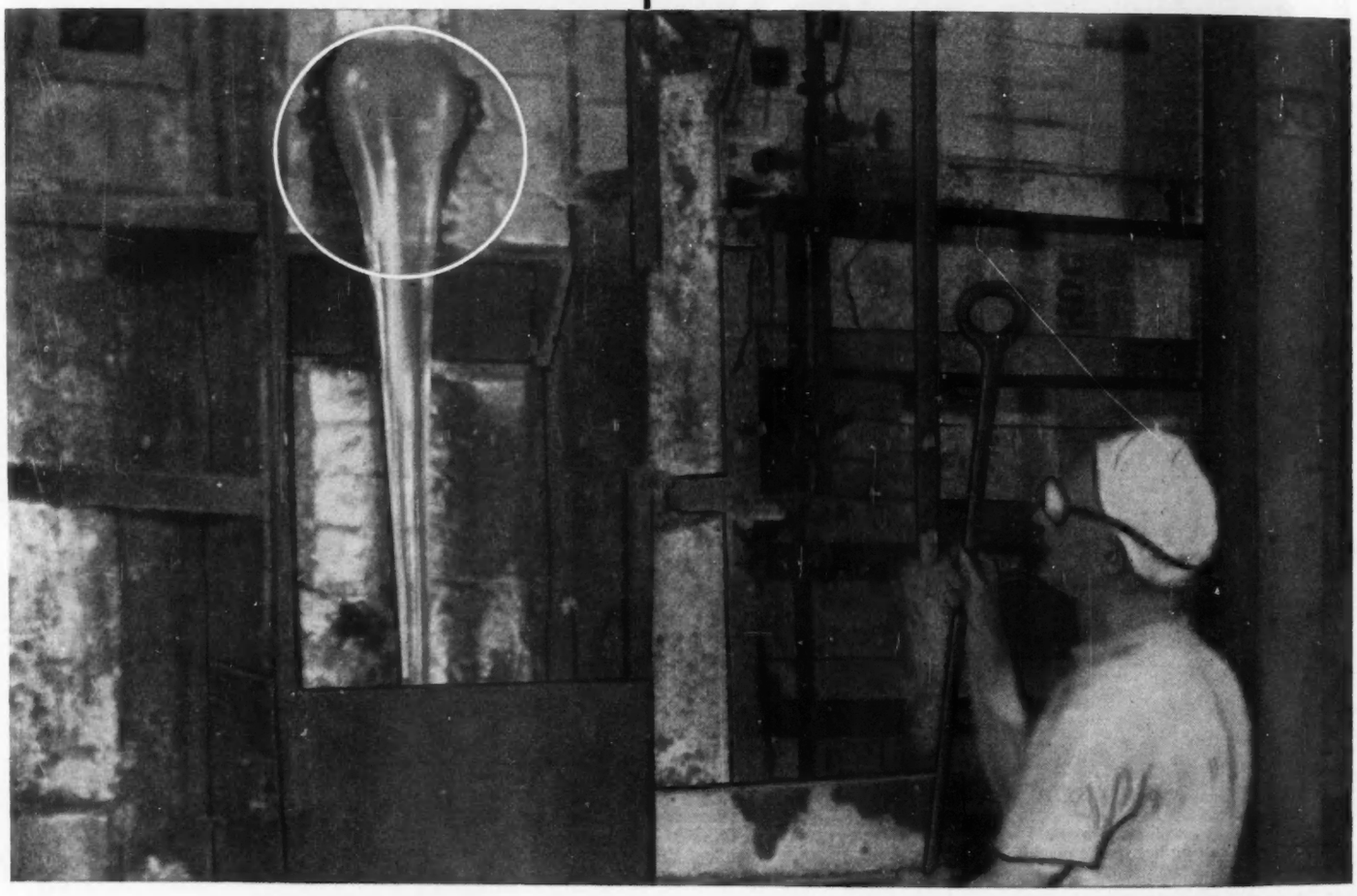
LLOYDS

Britain's Best Equipped Steel Foundry

F. H. LLOYD & COMPANY LTD., P.O. BOX 5 JAMES BRIDGE STEEL WORKS DARLASTON JAMES BRIDGE 2401

AT HIGH TEMPERATURES...

Now they're using NIMONIC alloys



At Joseph Crosfield & Sons Ltd., sodium silicate (better known as the "water-glass" used in preserving eggs) is produced by a continuous process. Soda ash and silica are fed together into an oil-fired furnace maintained at a temperature between 1,300°C and 1,400°C. When the materials fuse, molten sodium silicate streams out of the furnace and falls into buckets mounted on an endless chain. The temperature of the molten silicate at this point is around 1,000°C and in the past this often led to early failure of the furnace lip and therefore resulted in costly interruptions to production.

To overcome this problem, Joseph Crosfield & Sons Ltd., manufacturers of "Persil" and the largest producers of sodium silicate in the United Kingdom, use Nimonic 75 for the furnace lip. With its good strength properties and corrosion-resistance at elevated temperatures, this Wiggin nickel alloy gives four times the working life of any metal or refractory material used before.

This application is typical of the many ways in which the Nimonic Series of high temperature alloys is increasing efficiency in industrial processes which involve severe temperature conditions.

OUR TECHNICAL SERVICE
is available to assist those with problems involving corrosion or high temperatures.

'Nimonic' is a Registered Trade Mark

HENRY WIGGIN & COMPANY LIMITED *WIGGIN STREET · BIRMINGHAM 16*

TGA HT3

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ROTARY SHAFT SEALS

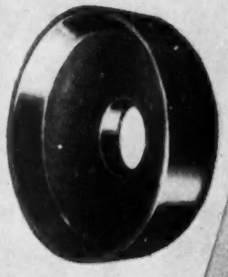
In leather and synthetic rubber for all requirements from ¼" up to 36" shaft; in built-up type or bonded.

CYLINDER LINER SEALS

Covering a wide range of sizes and suitable for applications where precision and high-class finish, together with the correct compounding of material, are essential.

"ROMET" FACE TYPE SEALS

For all water pump and similar applications.



RECIPROCATING SEALS ("C" & "U" RINGS)

For all types of hydraulic and pneumatic applications.

CUSTOMERS' SPECIFICATION SEALS

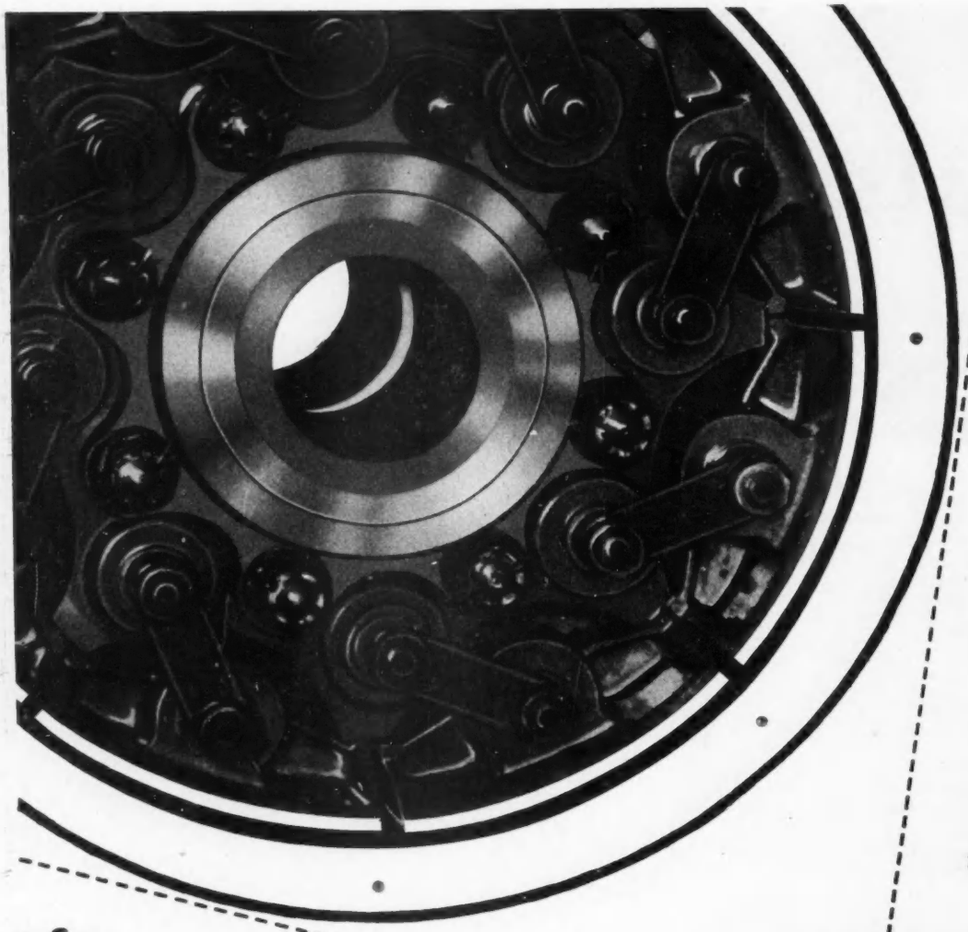
All types of seals are made to customers' own requirements. Our technical representatives will be pleased to call and discuss your problems.

Edward the Confessor

Edward the Confessor (d. 1066) became king in 1043, after the death of Hardicanute. He was so called because of his reputation for sanctity. His virtues were those of a monk rather than of a king and in his latter years he was primarily interested in the building of a new Abbey at Westminster.

The Authority on Seals

SUPER OIL SEALS & GASKETS LTD., Factory Centre, Birmingham, 30

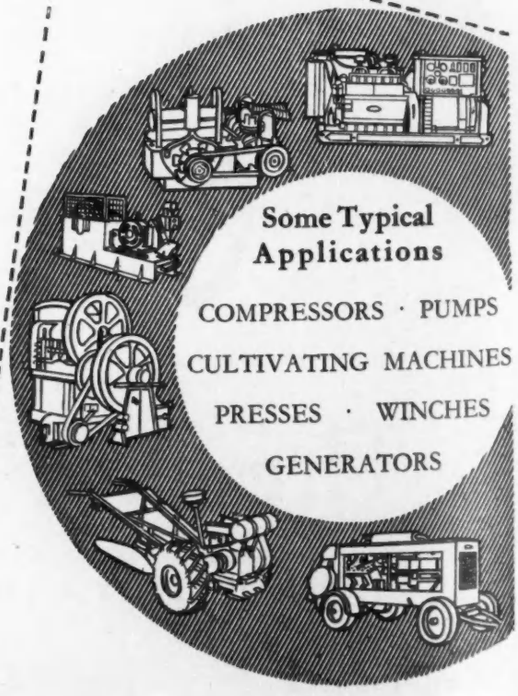


Used as a flexible coupling or automatic clutch, the 'TWIFLEX' simplifies assembly and reduces wear and tear on engine or electric motor drives

'TWIFLEX' SHOCKLESS POWER TRANSMISSION

Thousands of 'TWIFLEX' couplings are working in almost every country in the world on all types of industrial drives. The flexibility of the 'TWIFLEX' design adds years to the life of machine bearings, motors and switch gear. By permitting freedom at starting, standard squirrel cage motors can be used even for heavy inertia loads.

Write or 'phone for our revised brochure "Shockless Power Transmission" — it will tell you how the 'TWIFLEX' coupling can overcome your power transmission problem.



'Twiflex' Automatic Couplings

* compensate mal-alignment * damp torsional vibrations
* absorb shock * provide overload slip protection

TWIFLEX COUPLINGS LIMITED

(one of the Sheepbridge Engineering Group)

The Green, Twickenham, Middlesex

Telephone: Popesgrove 2206/9. Telegrams: TWIFLEX, Twickenham.

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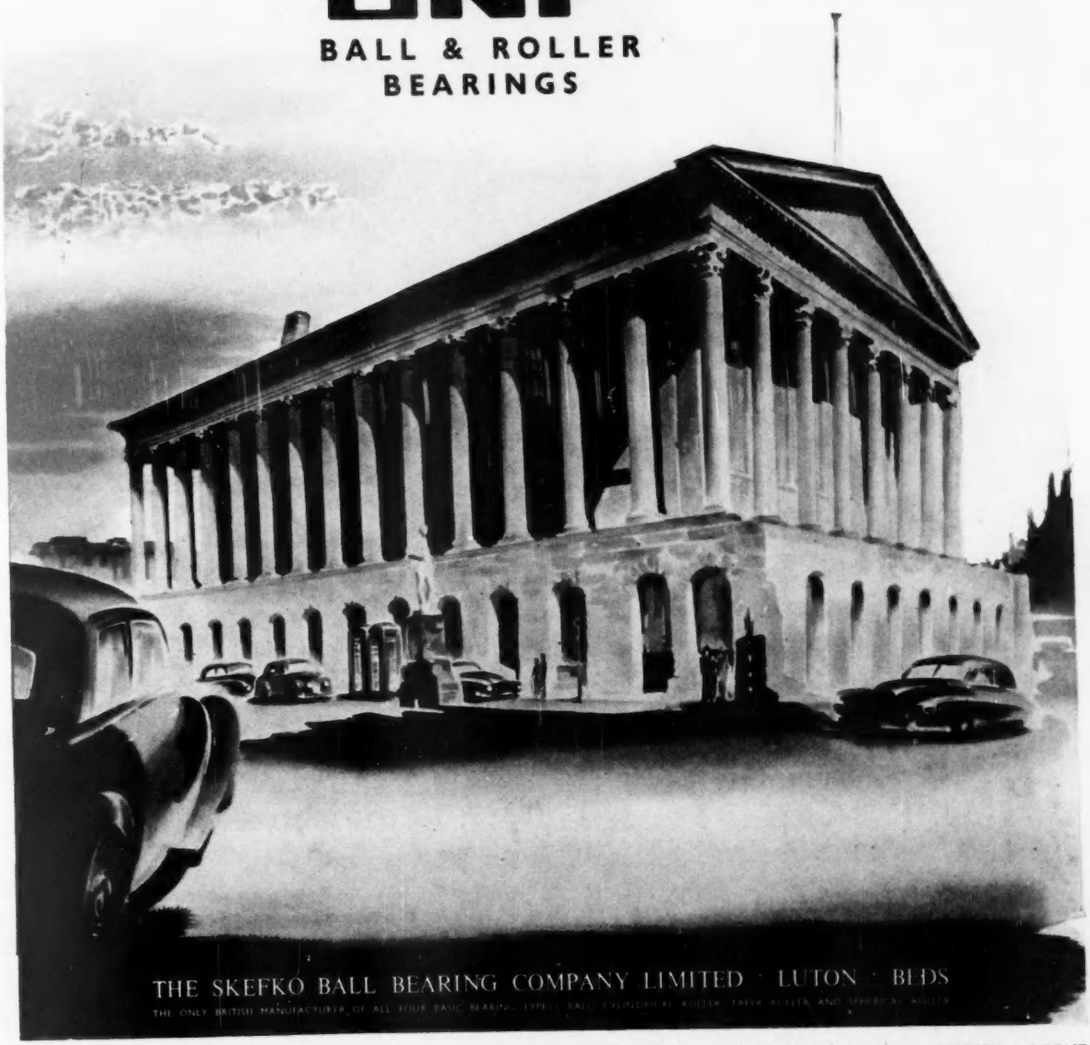
Birmingham—England's first provincial city and one of its busiest workshops. A vital factor in maintaining the smooth, uninterrupted flow of goods from this great industrial centre is an on-the-spot supply of high quality precision ball and roller bearings, and a source of expert technical advice on their use and application. All this—and the whole resources of a world-wide organisation, are readily available to all users of anti-friction bearings in the Birmingham area from Skefko's office in Broad Street.

182-3, BROAD STREET, BIRMINGHAM 15

Tel: Midland 3054/5 *Grams: Skefko, Birmingham* 15

SKF

BALL & ROLLER BEARINGS



One of a series of advertisements featuring the main towns where **SKF** service is centred. Other **SKF** offices are at:—ABERDEEN · BELFAST · BRISTOL · CARDIFF · DUBLIN · EDINBURGH · EXETER · GLASGOW · LEEDS · LEICESTER · LIVERPOOL · LONDON · LUTON · MANCHESTER · NEWCASTLE UPON TYNE · NOTTINGHAM · SHEFFIELD · SOUTHAMPTON

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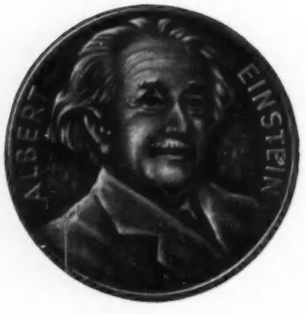

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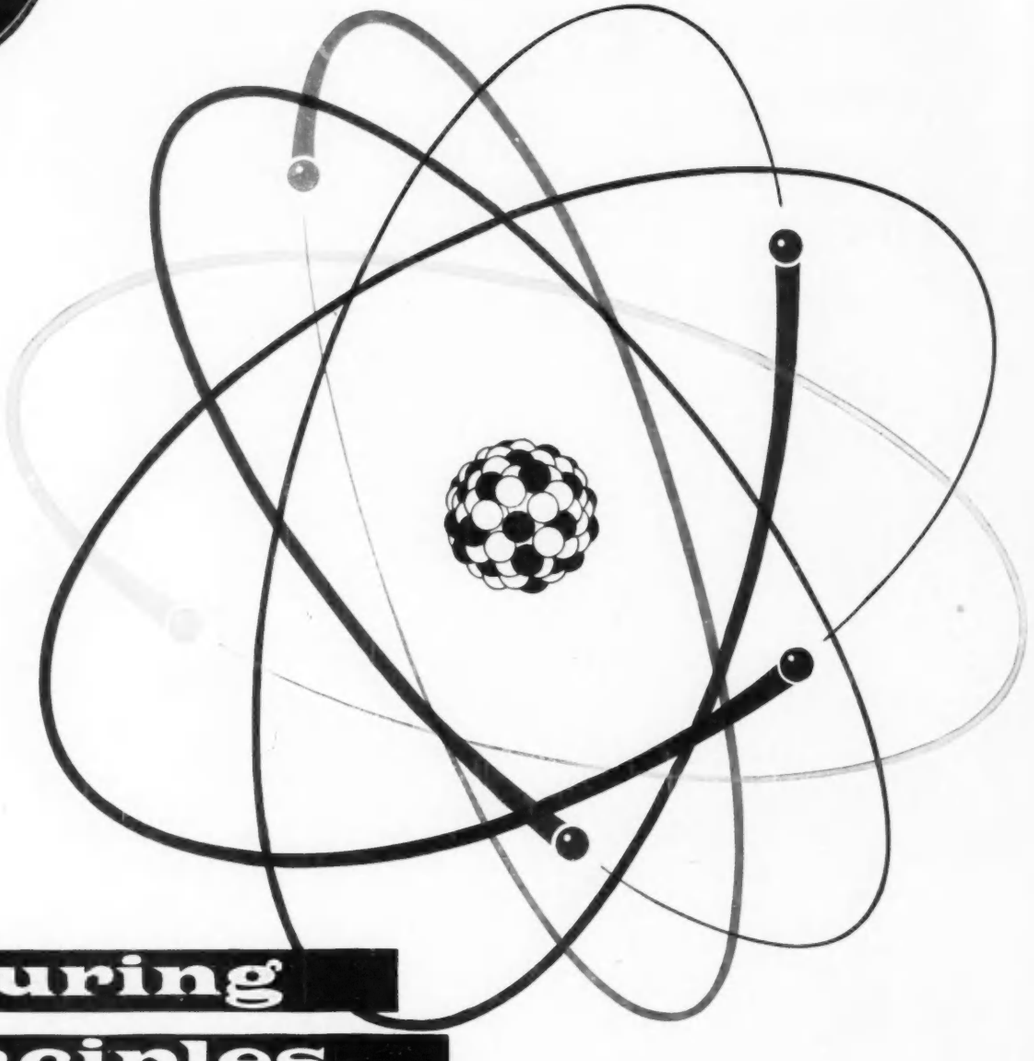

Enduring Principles

Albert Einstein — probably the greatest mind of our age — first published his famous Theory of Relativity over fifty years ago. How scientifically true were his observations is only too well-known by our own atom-age generation. Only time can tell what use mankind will make of this enormous power — but there is no doubt about his increasing ability to vary the basic theme of the great scientist's discovery.

In their own less violent way, Vokes too are conscious of how valuable are proved principles when applied to the field of scientific filtration. Throughout the machine world today, Vokes filters are accepted as supreme because of certain tried and true advantages — inside-to-outside flow, the use of *felt* fabric filter elements, and a direct-flow by-pass device that is absolutely foolproof.

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LONDON OFFICE: 123 VICTORIA STREET · WESTMINSTER · S.W.1
VOKES (CANADA) LTD., TORONTO · VOKES AUSTRALIA PTY. LTD., SYDNEY
REPRESENTED THROUGHOUT THE WORLD

VOKES
Pioneers of scientific filtration

Centrifugal Castings

Firth-Vickers have developed reliable centrifugal casting techniques to ensure that the finished product is best suited to the purpose for which it is made.

Advice based upon a unique fund of experience is readily available.

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Telephone: Sheffield 42051

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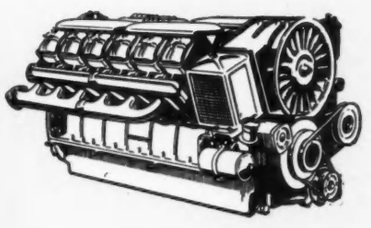

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Whatever the requirements...

Dear Sir,
delivery to above Works for two Overhead
Travelling Cranes with a span of 40'
to travel along a common gantry 76' long
Joseph Booth & Bros.,
Rodley,
Leeds.

Heavy Steelworks Duty or

Light Factory Duty

40 feet span or

120 feet span

Intermittent Duty or

Continuous Duty

Lifting capacity 3 tons or

Lifting capacity 200 tons

1000 maximum hours per annum or

5000 maximum hours per annum

a BOOTH standard electric overhead crane will DO THE JOB!

THE Booth method of classifying overhead electric travelling cranes to suit varying service factors means that from a range of five classes of cranes, it is possible to offer a standard crane to serve almost any industrial requirement. We manufacture cranes for light duty up to continuous process cranes for Steelworks, and installations within this range have been carried out in many factories and Steelworks in this country and abroad. Grading of cranes effects considerable economies by making it possible to standardise components within each group whilst still retaining the advantages from the purchaser's point of view of being able to choose a crane to suit the duty required.

The Booth Handbook of Overhead Cranes is a comprehensive publication containing practical information which will be of interest to crane users. It fully explains the Booth method of classifying overhead cranes to suit varying service factors and gives detailed information and hints on fixing crane particulars which would be of assistance to any firm contemplating additional craneage.—

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Telephone: Pudsey, 3168. Telegrams: "Cranes," Rodley.

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Switchboard and Portable A.C. and D.C. Indicating and Recording Instruments

RECORD

"Cirscale" Electric Tachometers, Insulation and Resistance Test Sets Moving Coil Relays, etc.

And it will be just as fresh and clean as in the countryside if it has been purified by Heather Multi-brush Air Filters. For Heather Filters adopt Nature's principle of cleaning the air by means of a fine screen of intermingling hairs. Like nature, too, they do their work efficiently, and maintenance is extremely simple—there are no messy fluids to apply and nothing to replace. Get in touch with us if you have an air filtration problem.

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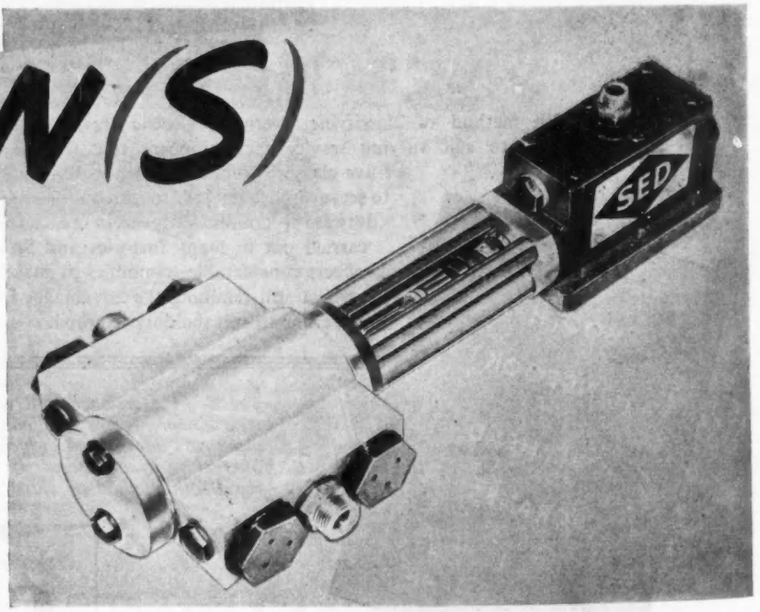

The S.E.D
'NEUMO' Mk. III
PNEUMATICALLY OPERATED PUMP UNIT

THE MOTOR

- ★ Two moving parts only.
- ★ Hardened and ground piston and valve.
- ★ Cast iron body with honed bore.
- ★ Non-stalling.
- ★ Negligible air consumption.
- ★ High power output.

THE PUMP

- ★ Double acting.
- ★ High efficiency.
- ★ Self-contained valves.
- ★ Easily serviced.
- ★ Pumps liquids up to 200 deg. F.

SIMPLICITY MEANS RELIABILITY

TYPICAL PERFORMANCE FIGURES

Air Pressure	60 lbs. P.S.I.	60 lbs. P.S.I.
Consumption	2½ Cu. F.P.M.	2½ Cu. F.P.M.
Delivery	45 gals. P.H.	120 gals. P.H.
Del. Pressure	30 lbs. P.S.I.	5 lbs. P.S.I.

WIDE RANGE

Owing to the design and materials employed in its construction, the "Neumo" Mk. III Pump Unit is capable of handling a very wide range of materials such as paint at 200 deg. F., petrol, oils, from paraffin to high viscosities, Solvex, Mangersol, Basol, Trichlorethylene and all types of cellulose solvents, etc.

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SHOT BLAST MACHINES

for

SHOT PEENING

WORK HARDENING

J. W. JACKMAN & CO., LTD.,

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PRESSURE VACUUM COMPOUND GAUGES

of finest British Craftsmanship

David Harcourt gauges are manufactured in a wide range of types and sizes. Their ranges cover from 30 inches of vacuum and to pressures of 10,000 lb. per square inch.

DAVID HARCOURT LIMITED

LINKULA WORKS, COVENTRY ROAD, BIRMINGHAM, 10
Phone: Victoria 1051-1052. Grams: Linkula Birmingham 10
A member of SMITHS Industrial Instrument Division

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HAND PUMP FOR DOWTHERM

Specially designed for this chemical.
Tested to 150 lbs. per square inch hydraulic pressure.
Supplied in a range of sizes.

ZWICKY LTD.

Trading Estate . Slough . Bucks.
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SPECIALISTS IN PUMPING AND FILTERING EQUIPMENT

Aeroflex

ENERGY LIMITING CARTRIDGE FUSES TO CLASS P

This new range of Aeroflex Fuses (AD and FC type) Category 440 AC5 Class P - is fully interchangeable with the former patterns and is now supplied in all listed Fluvent Switch and Fusegear. They offer refinements in performance, primarily due to the following factors:-

TECHNICAL DATA

Publication CF2 deals extensively with the subject and affords interesting data. A copy will be forwarded gladly to enquirers and students.

These characteristics are extensively detailed in this new publication, CF2, which reproduces actual oscillograms obtained during ASTA tests.

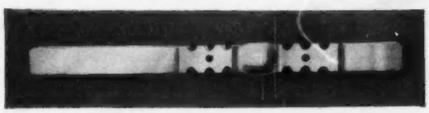
(1) The proved Breaking Capacity is raised from 33 to 46 K.A.

(2) The Energy Limiting is uniformly developed throughout the range.

(3) The fusing Factor is standardised at 1.25 throughout the range.

(4) The cartridge cases are ceramic instead of fibre.

(5) The end caps are fixed instead of being detachable as in the AF pattern, and re-wiring is normally carried out by returning blown cartridge fuse-links to the factory and not on site.



★ The latest types of Aeroflex fuse element as employed in the AD and FC type Energy Limiting Fuses.

Parmiter Hope & Sugden Ltd.

FLUVENT ELECTRICAL WORKS · LONGSIGHT · MANCHESTER 12

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dmPH83

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Manufactured in Sizes 5" 8" 12" 18" 24" diameters.
Cast Iron, Stainless Steel and Non Ferrous Alloys.
Temperatures up to 250°C.
DRIVES: BELT, DIRECT COUPLED, VARIABLE SPEED IF REQUIRED.

We can offer a choice of flexible Rotor Vanes i.e. Vitrathene, Silicon Rubber, Fluon and Solid Steel.
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MIKRO - PULVERISER (FINE)
- ATOMISER (ULTRA FINE)
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Exclusive Manufacturing Licencees for Pulverising Division, Metals Disintegrating Company Inc., Summit, New Jersey, U.S.A.

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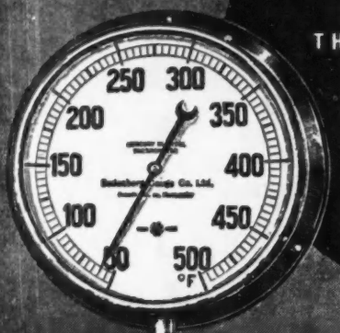
MERCURY-IN-STEEL AND VAPOUR THERMOMETERS

To the highest standards of accuracy

Illustration shows Mercury-in-Steel Distance Thermometer

Please write for catalogue sect. 27



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BUDENBERG GAUGE CO. LTD.,

BROADHEATH, Nr. MANCHESTER.

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'Phone: GERrard 4822-3 'Grams: Pyrometer, Piccy, London. dmBU4

Here is the perfect jointing for high pressure smooth surface or screw unions!

Tested and recommended by the Ministry of Supply (MTV Branch) Reference No. VG.6/300/FIR for export to tropical countries

OSOTITE—the modern scientific sealing which has been proved by rigorous tests to be the perfect jointing for smooth surface and screw unions. OSOTITE is a simply applied liquid compound, impervious to heat, petrol, oil, grease, water and steam, which ensures in a few minutes a HIGH PRESSURE GAS AIR or WATER-TIGHT JOINT.

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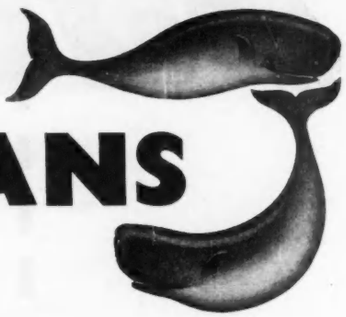
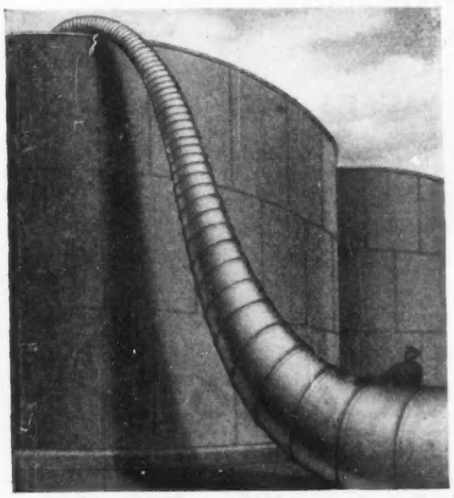


or TITANS



SPIRATUBE

A simple machine-shop installation or a giant job of fume extraction—industry today is specifying SPIRATUBE the light, tough, flexible ducting with a wide choice of diameters, from 3" to 30"—and in a variety of coverings.

SPIRATUBE is easily and quickly installed by your own maintenance staff—no structural alterations—no heavy hangers—no special elbows. SPIRATUBE is economical too, because it can be dismantled and used again and again. It is so light and retractable that one man can carry many feet with ease.

Write today for the SPIRATUBE Brochure which illustrates what this versatile ducting will do. Put your problem up to our design engineers. They will be glad to advise you without cost or obligation. The address is Flexible Ducting Limited, Maryhill, Glasgow

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Telephone: MARyhill 3729 Telegrams: Flexiduct, Glasgow, N.W.

AN ASSOCIATE COMPANY OF GEORGE MACLELLAN & CO. LTD. ESTABLISHED 1870

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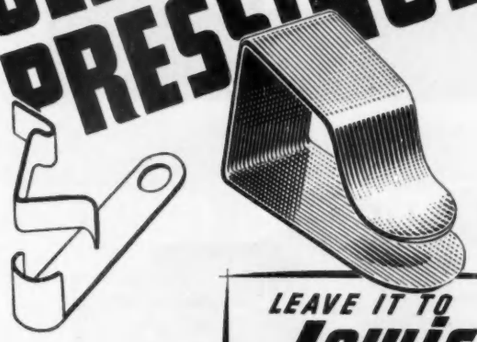

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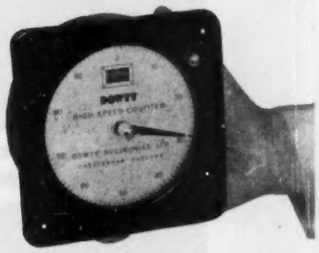
ELECTRICAL COUNTING
up to 75 counts per second

This resettable electro-mechanical unit has become increasingly popular for a wide range of industrial applications. It can be operated in many ways from relays and cam-operated contacts or from photo-electric and cold cathode discharge circuits.



The Dowty High Speed Counter HSC

There are other units in our range of equipment to solve your counting problems up to 20,000 per second.

Further details will be supplied on request

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SPECIALISTS IN ELECTRICAL COUNTING
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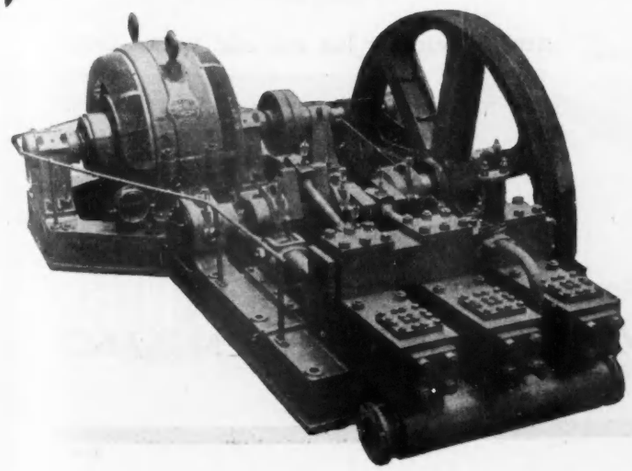
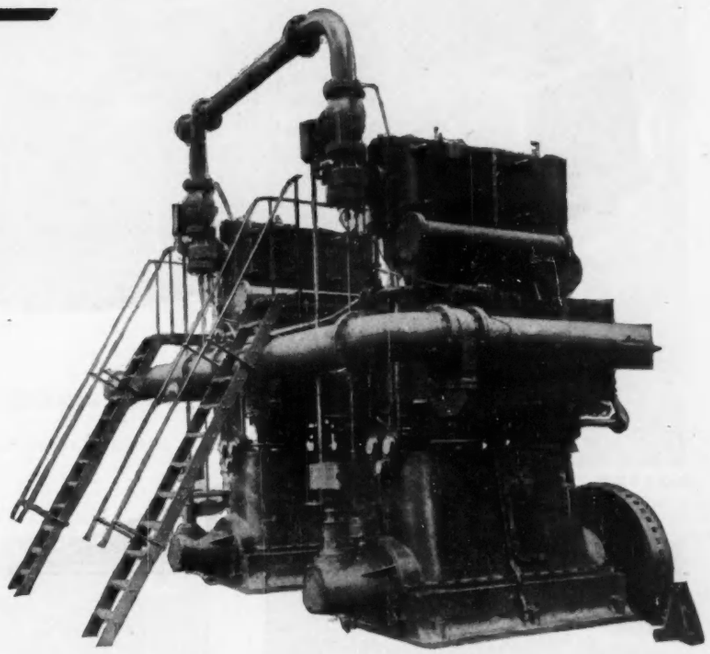
Telephone : Andoversford 391/2/3
Telegrams : "Invention," Cheltenham

HYDRAULIC PLANT
and
AIR & GAS COMPRESSORS
STEAM AND MOTOR DRIVEN



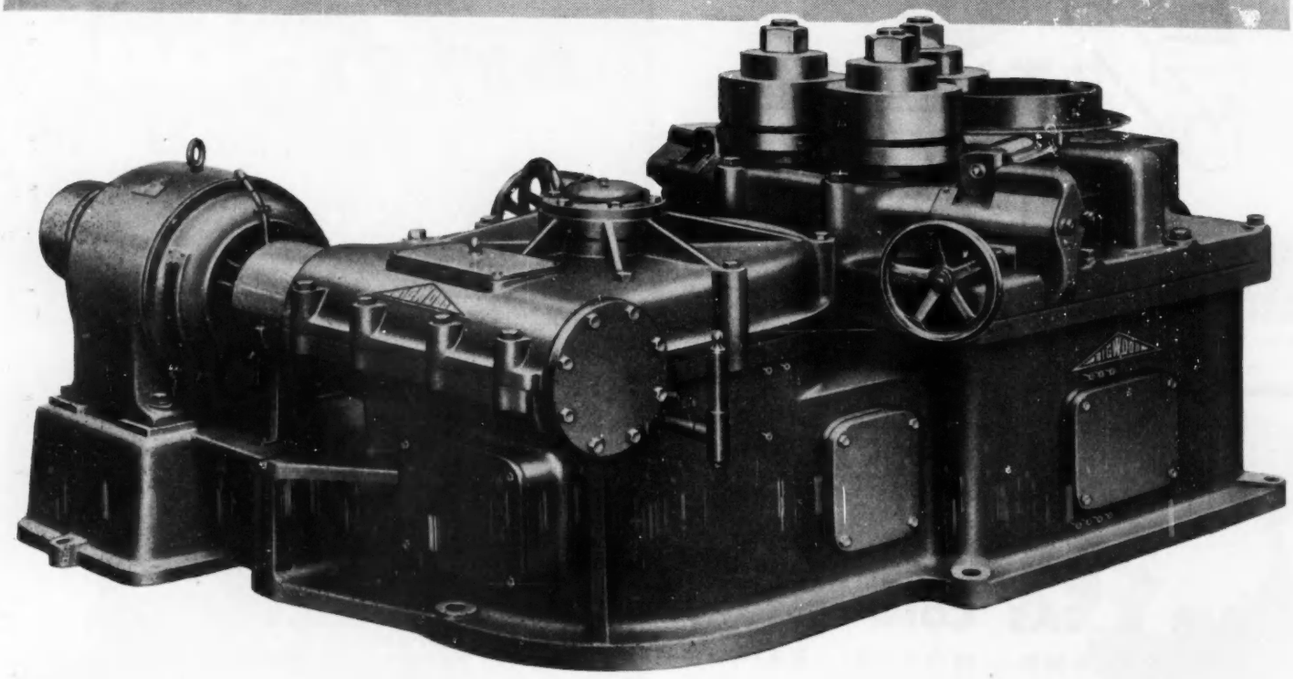


Left: One of a set of six motor driven, horizontal, three throw, single acting, Hydraulic Pumps made for the Port of London Authority.

Above: Two vertical, two crank, single stage, Gas Compressors; 3,333 cu. ft. per minute to 20 lbs. per sq. in.; r.p.m. 300; made for Dundee Corporation Gas Department.

FULLERTON, HODGART & BARCLAY LTD.
VULCAN WORKS · PAISLEY · RENFREWSHIRE

'OPEN-END' SECTION BENDERS

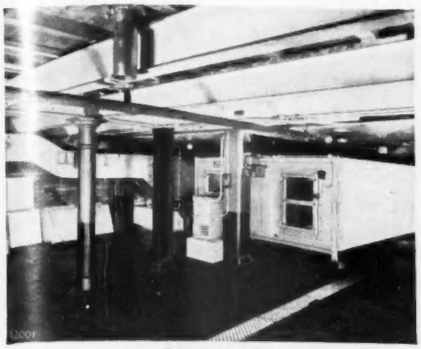


BIGWOOD

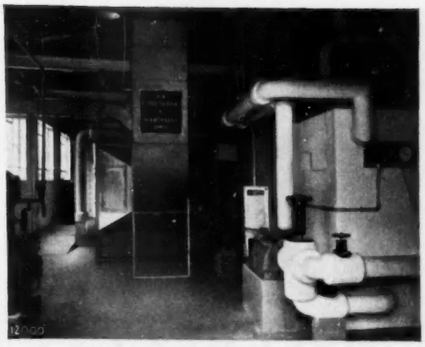
Vertical and horizontal 'open-end' section bending machines—for bar and structural steel sections for hot and cold work. 2-roll or 3-roll drive, with powered adjustment for the heavier sizes. Semi-'open-end' ring benders for wide flats.

JOSHUA BIGWOOD & SON LIMITED · WOLVERHAMPTON · ENGLAND

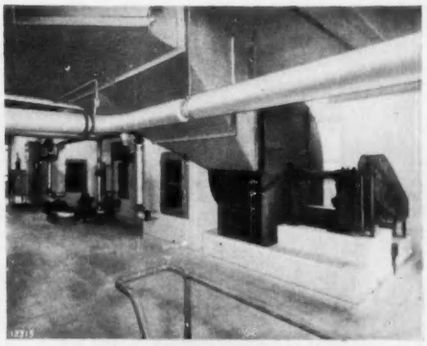
B 137



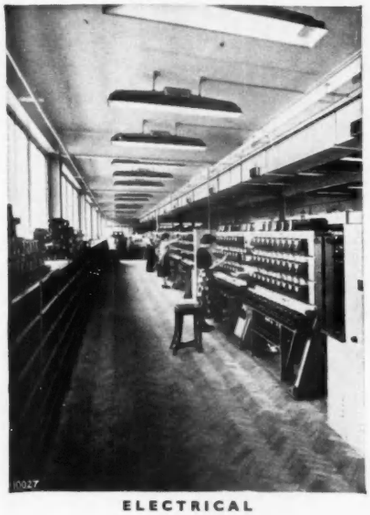
BREWING



PRECISION MACHINERY



INDUSTRIAL BUILDINGS



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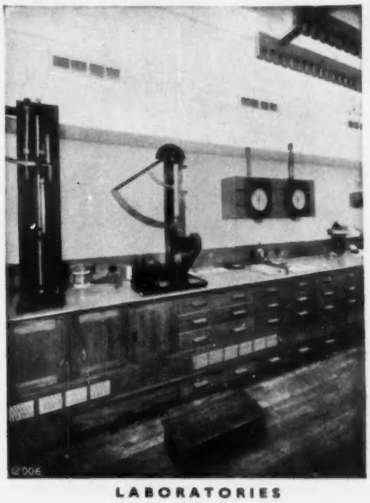
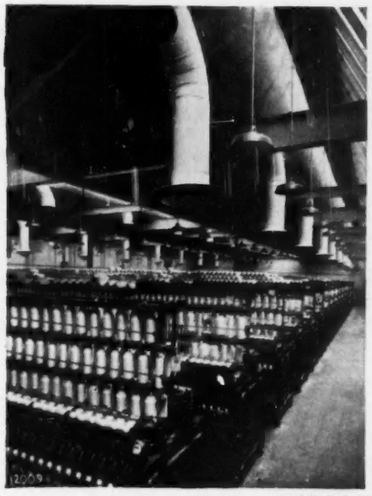


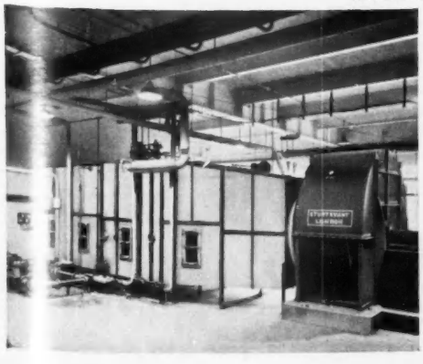
LABORATORIES

TOBACCO

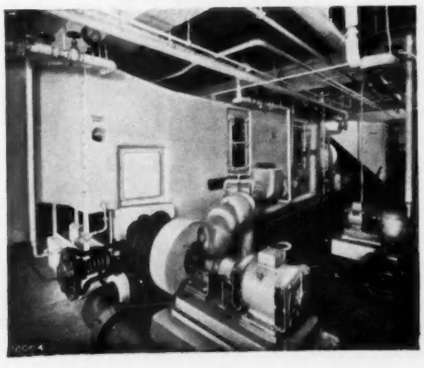


COTTON

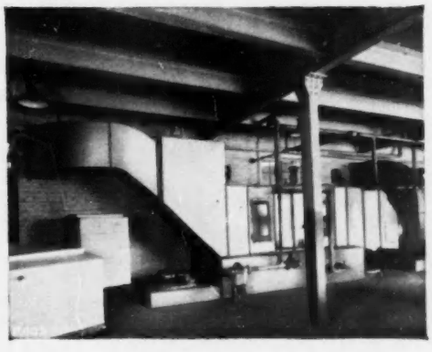
NYLON



PHARMACEUTICAL



PAPER



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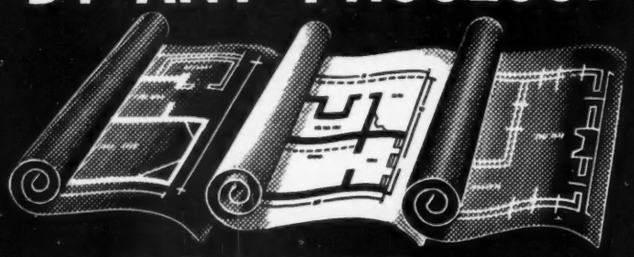

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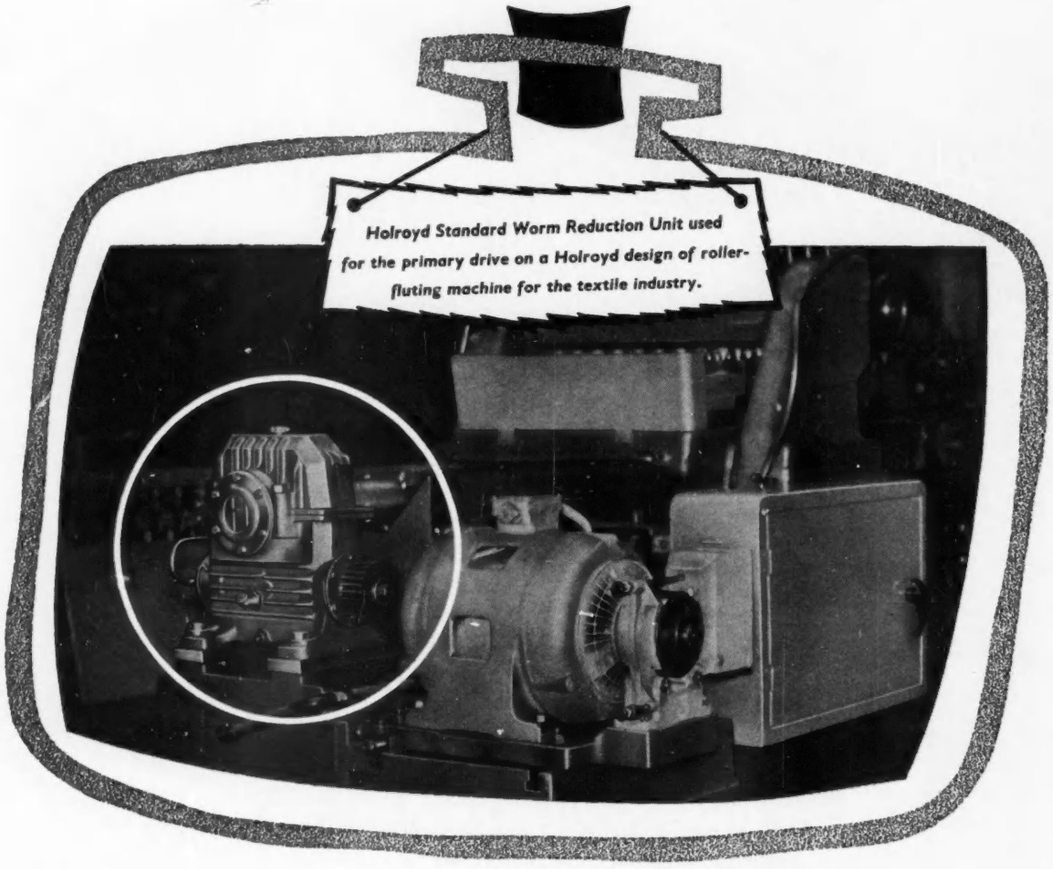
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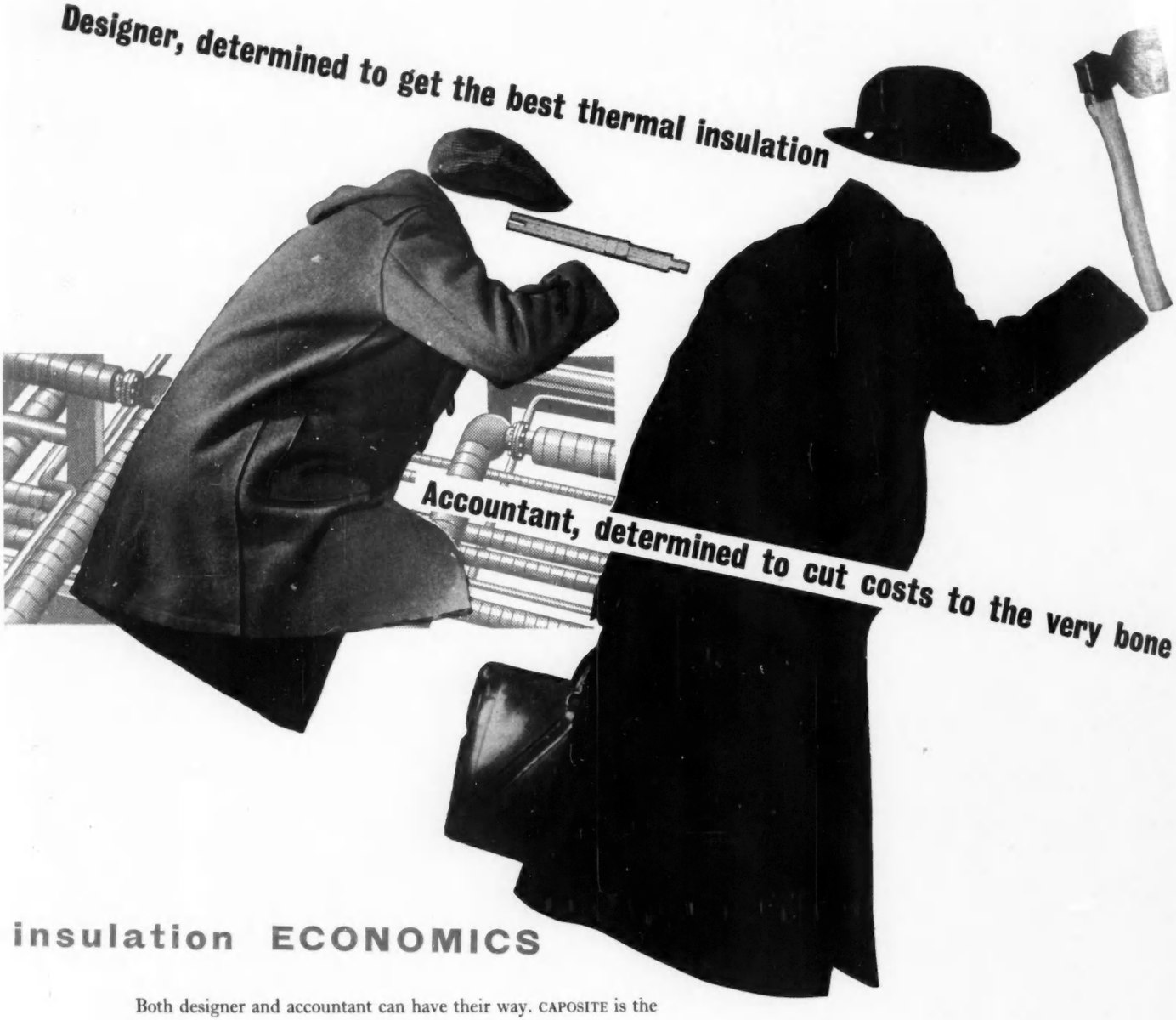

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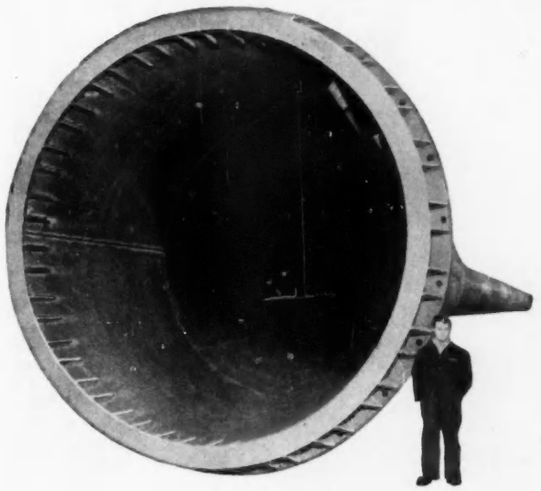

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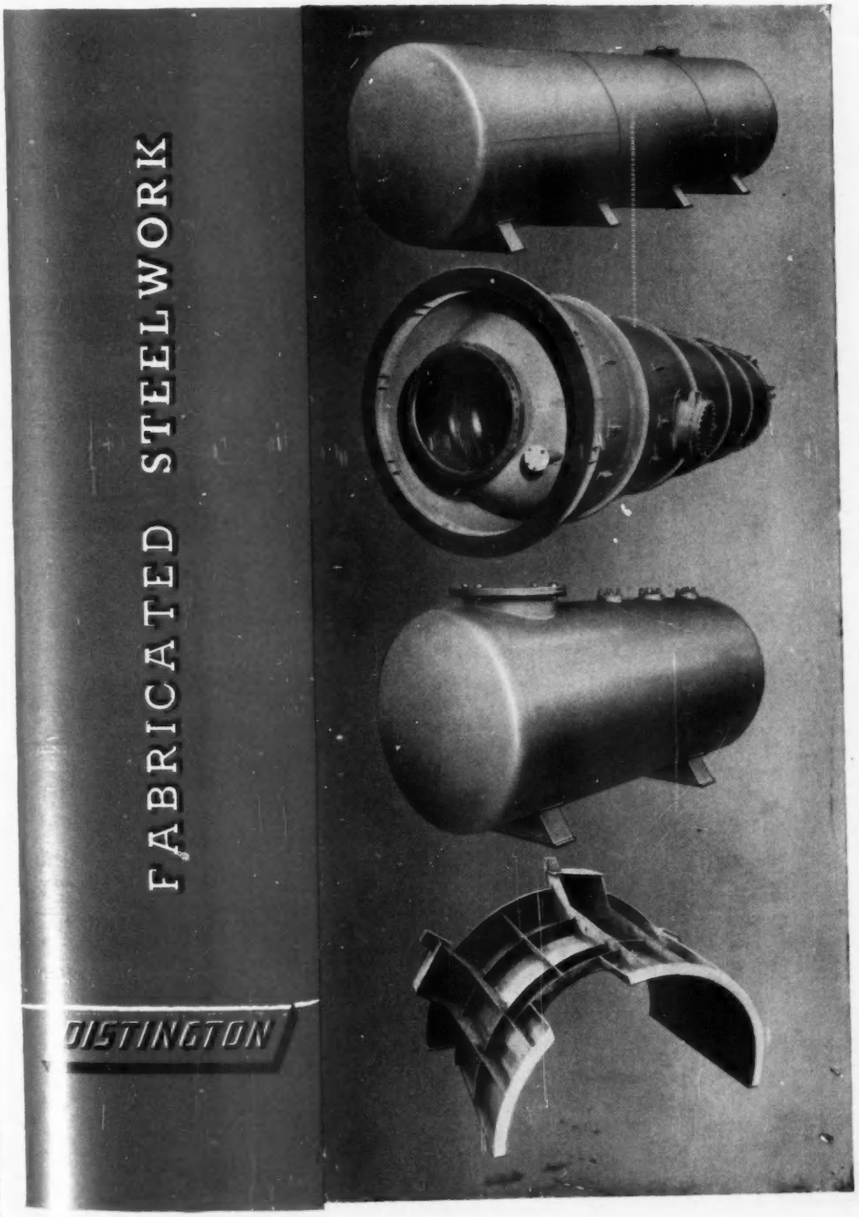

Storage vessels with plain or dished ends, agitators, reactor columns, open hearth furnace charging boxes, switchgear boxes, feed hoppers, and loading pockets, are a few of the products of that branch of our business devoted to fabricating in steel. We make products of this kind either to designs provided by our customers, or to specifications according to which we make the necessary drawings.

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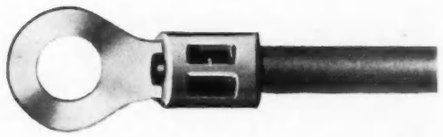
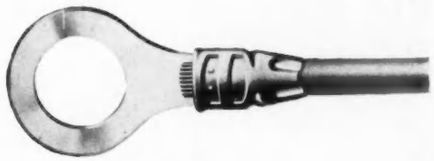
AMP Certi-crimp. Positive closure ensures

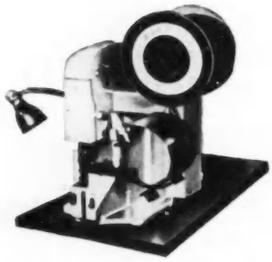


Finished termination — strong, neat, uniform

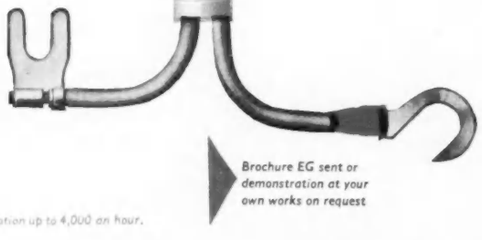
AMP Pneumatic hand tool. Eliminates operator fatigue. High rates of output.



Faston connector



AMP Automatic wire terminator. Uniform, precision installation up to 4,000 an hour.



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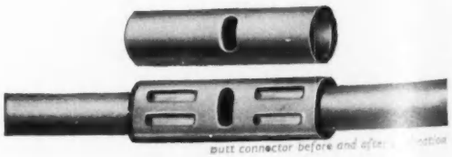

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Ahead of the present— —abreast of the future

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A SUMMARY OF THE CAPACITIES AND FACILITIES OF THE ENGINEERING COMPANIES FORMING

The HORSELEY Group

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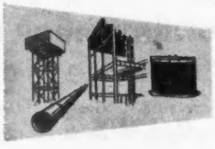
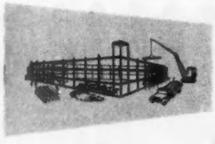
HORSELEY WORKS, TIPTON, STAFFS.



One of the oldest Engineering Companies in this country. Equipped to produce all forms of constructional steelwork particularly those of the larger order and including industrial platework. Pioneer manufacturers of Pressed Steel Tanks and large diameter steel mains.

CARTER-HORSELEY (ENGINEERS) LIMITED,
TIPTON, STAFFS. CROYDON AND SHEFFIELD



Specialists in steelwork erection and repair and maintenance of existing plant and structures. Its range covers sheeting and glazing of industrial buildings and fabrication of light structures from works and yards within easy reach of all parts of the United Kingdom.

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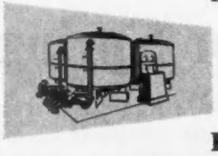
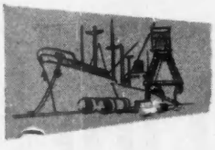


Manufacturers of Water and Effluent Treatment Plant, Water Softening Plant and Filtration Plant for all industrial processes.

RAILWAY MINE & PLANTATION EQUIPMENT LTD,
IMPERIAL HOUSE, DOMINION STREET, LONDON, E.C.2.



This Company handles all Export Selling for the Group. Agents in all principal territories of the world and touring representatives, based on London, permit very close liasion between overseas buyers and the technical departments of the Group.

HORSELEY GROUP

The services rendered by the Group are wide and comprehensive in their scope and closely co-operative in their functioning. This element of flexibility forms the keynote of the organisation, further detailed information about which is available on request, from Central Headquarters, Horseley Works, Tipton, Staffs.

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UNIVERSAL TESTING MACHINE
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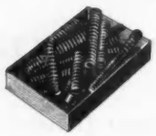
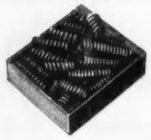
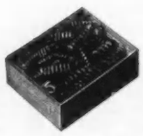
No. 1013. 1 gross Small Coil Compression Springs, ⅜" to 1¼" long, 3/32" to 7/16" diam., 24G to 19G. 6/- each



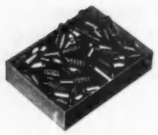
No. 760. 3 doz. Assorted Light Compression Springs 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6 each.



No. 98A. 3 doz. Assorted 1" to 4" long. ¼" to ½" diam. 19G to 15G. 5/6 each



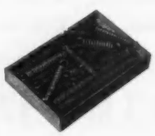
No. 757. Extra Light Compression. 1 gross Assorted. ¼" to ½", ¼" to 2" long, 27 to 20 S.W.G. 15/- each.



No. 388. ½ gross Assorted Small Expansion Springs. ½" to 1¼", 18G to 21G. 9/6 each.

No. 466. ½ gross Assorted Small Expansion Springs ½" to 1¼" long, 3/32" to 3/16" diam., 21G to 24G. 6/6 each.

No. 1024. 20 Compression Springs 12" long. ¼" to ½" diam. 24G to 18G, suitable for cutting into shorter lengths ; and 30 Expansions 1½" to 12" long, 5/32" to ⅜" dia., 22G to 16G, 24/- each.



No. 753. 3 doz. Assorted Light Expansion ½" to ¼" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6 each.

No. 758. Fine Expansion Springs, 1 gross Assorted ½" to ⅜", ¼" to 2" long, 27 to 20 S.W.G. 15/- each.

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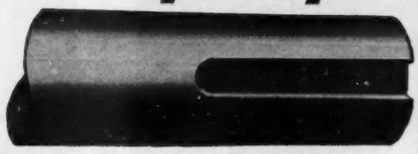

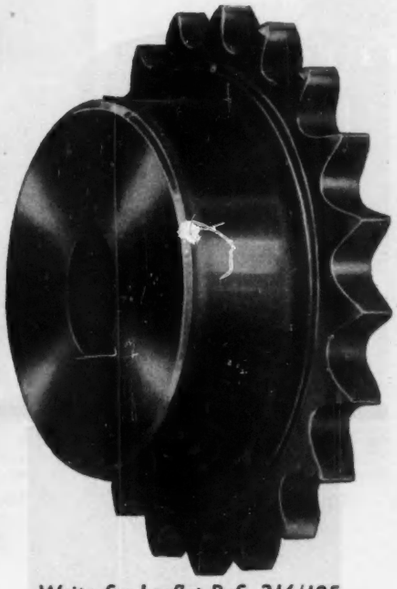

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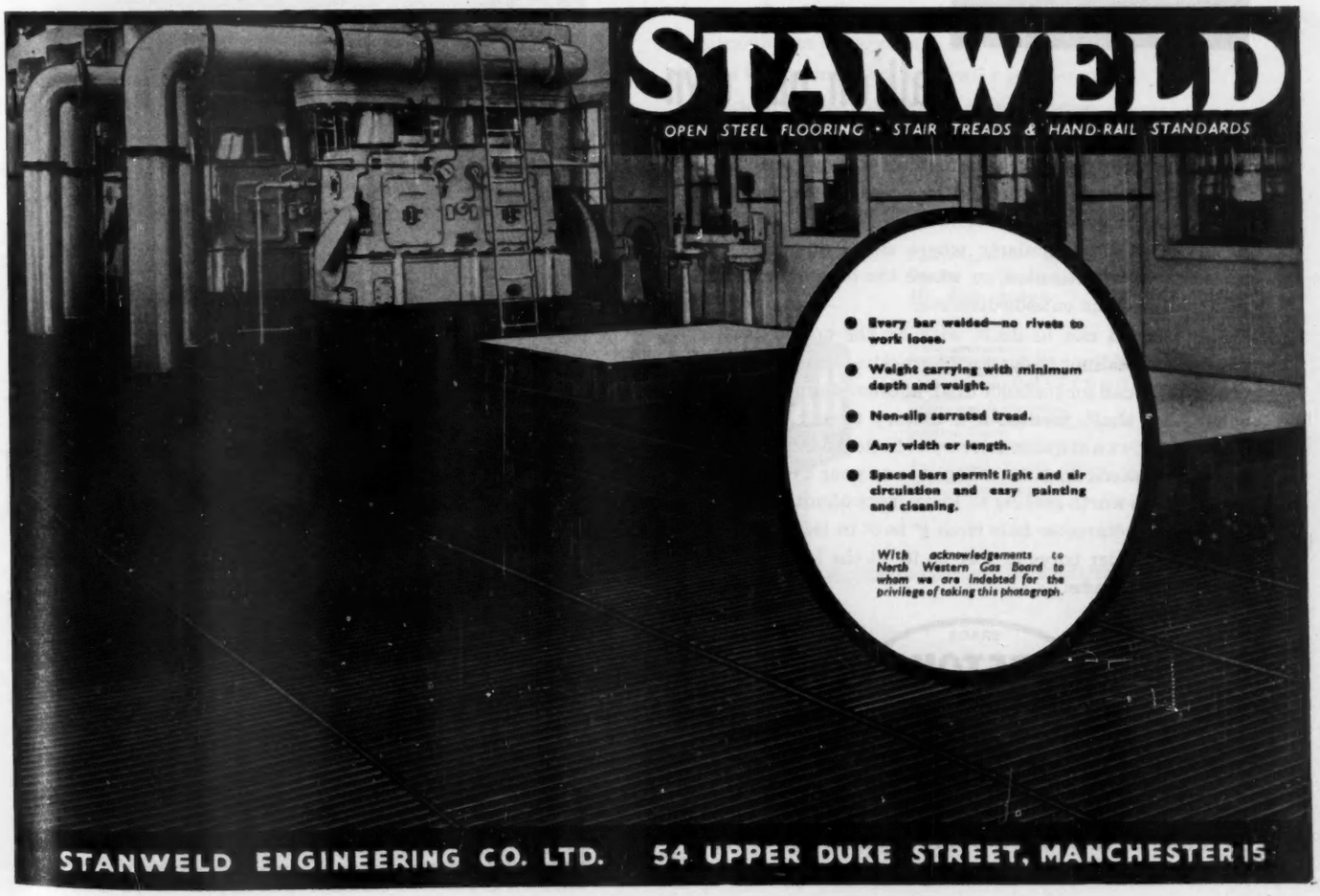
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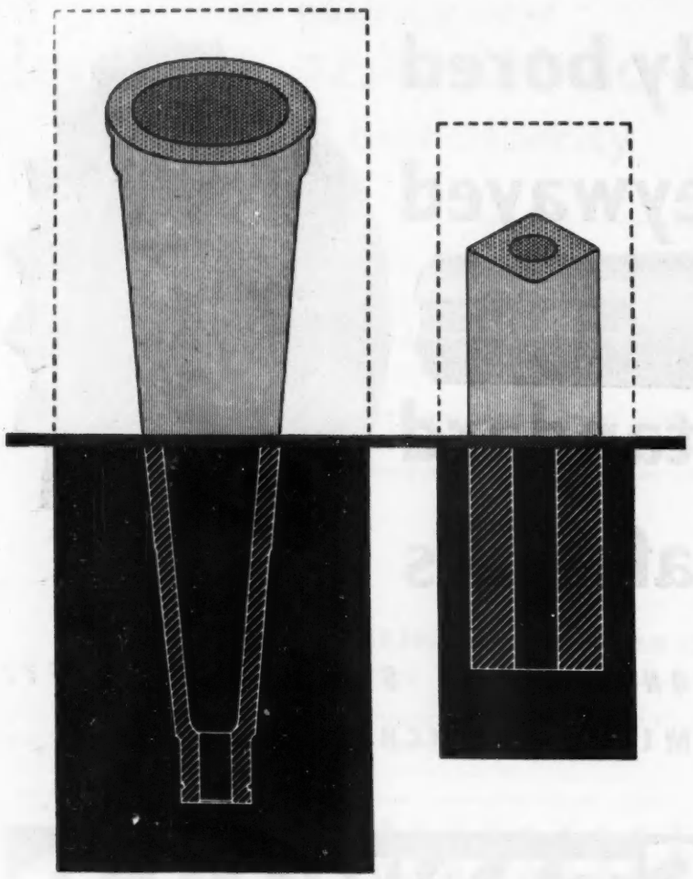

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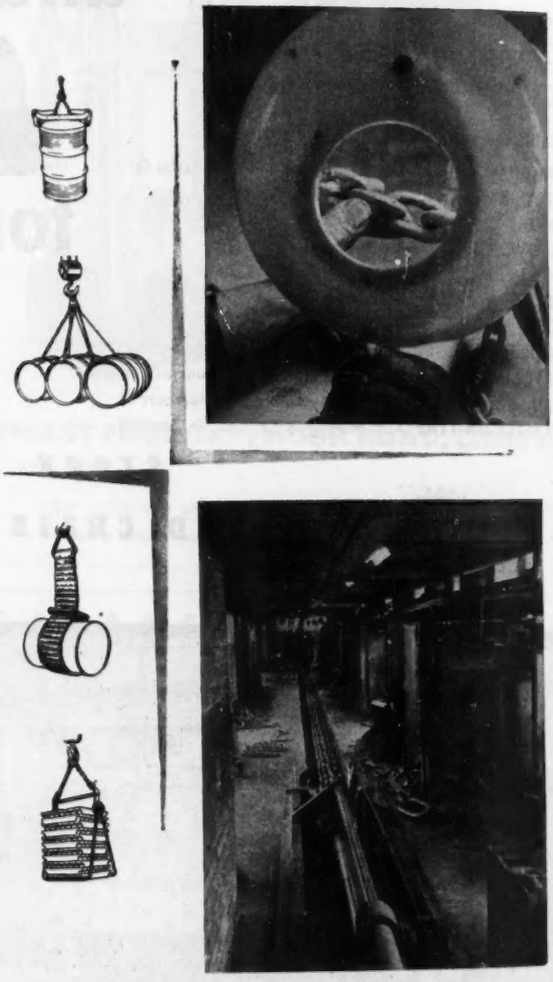

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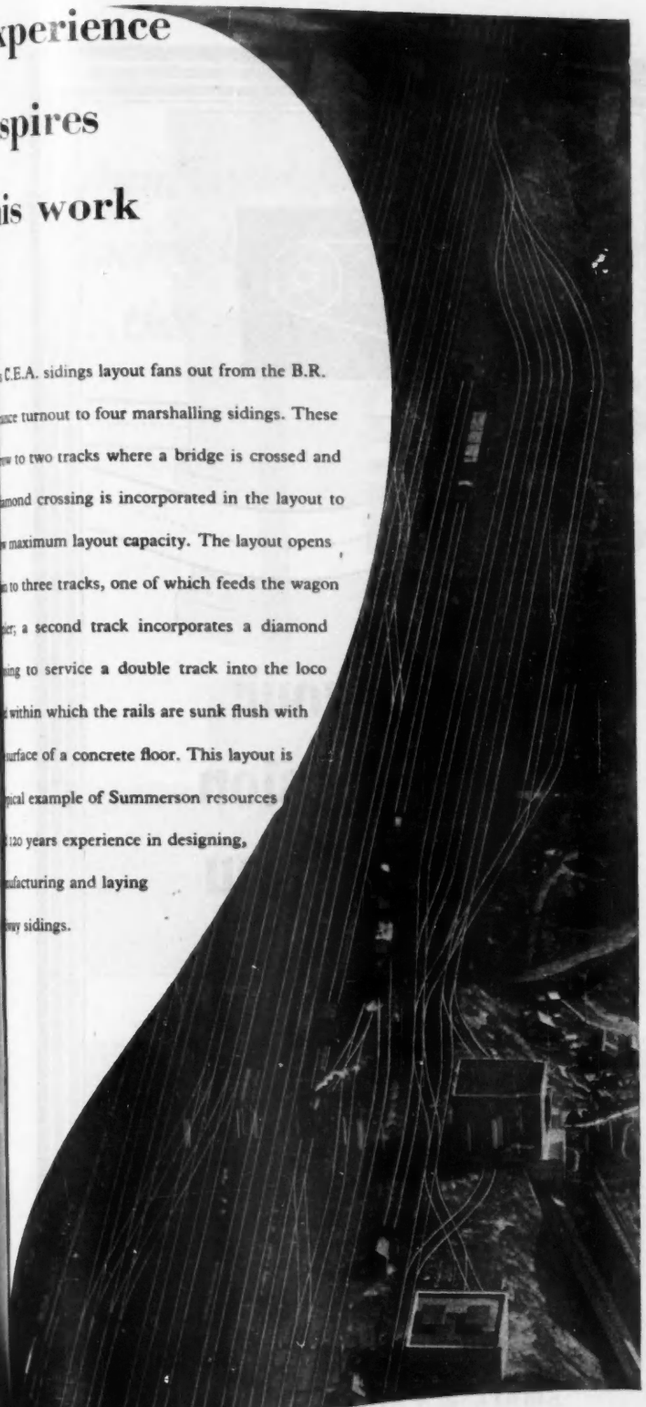

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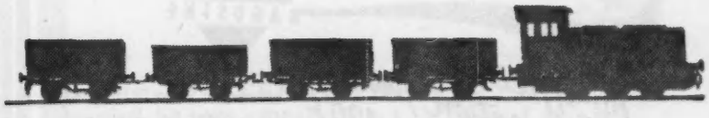

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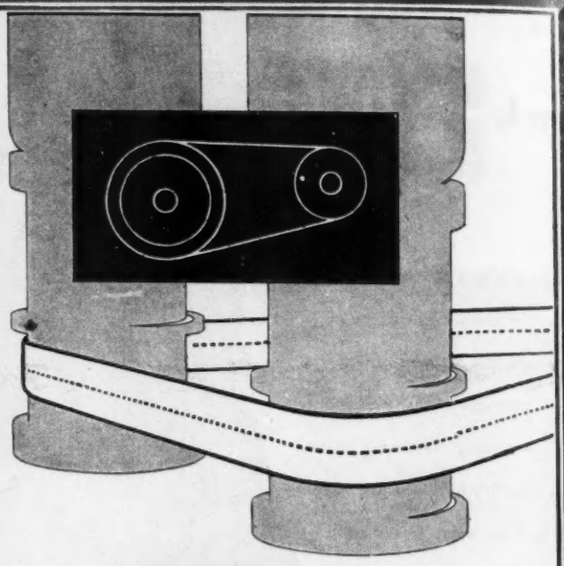

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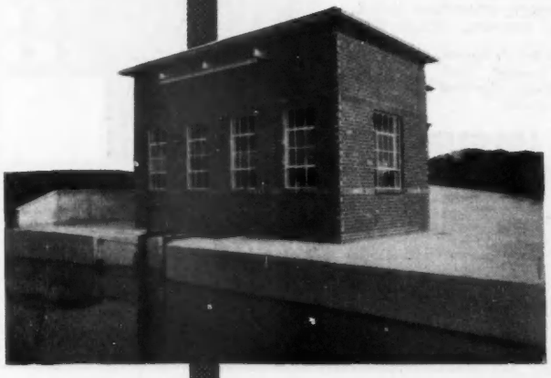

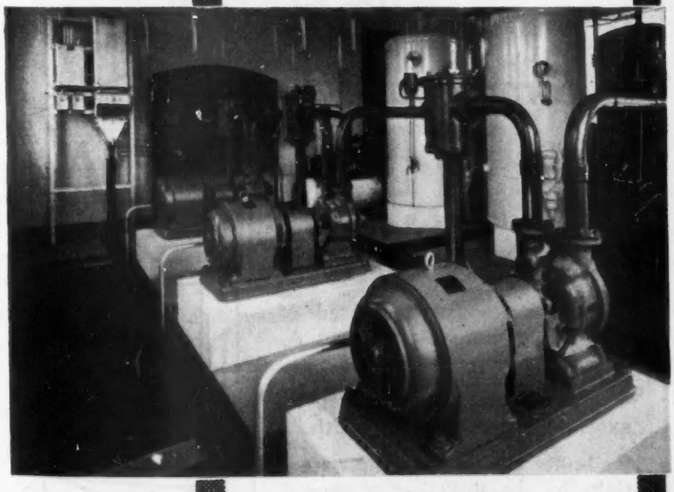

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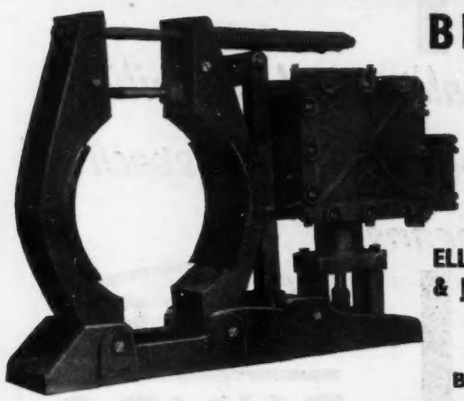

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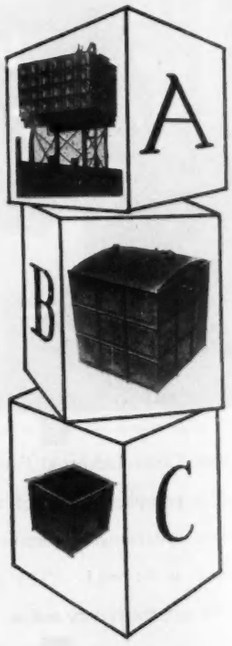

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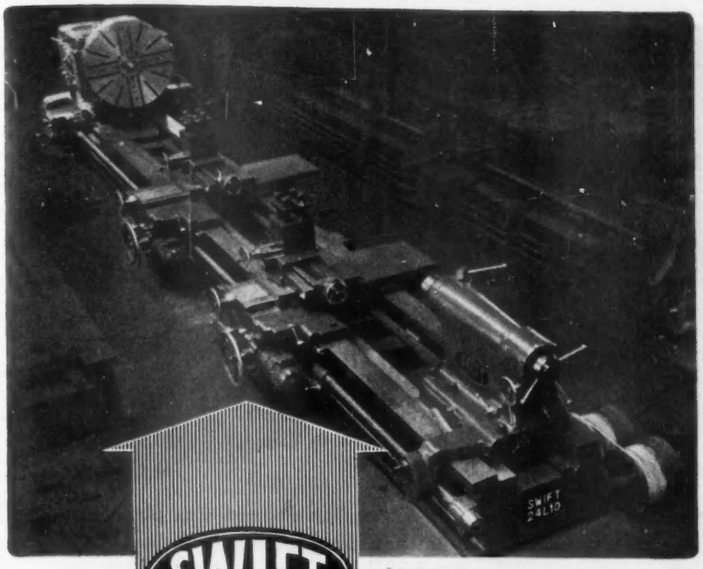

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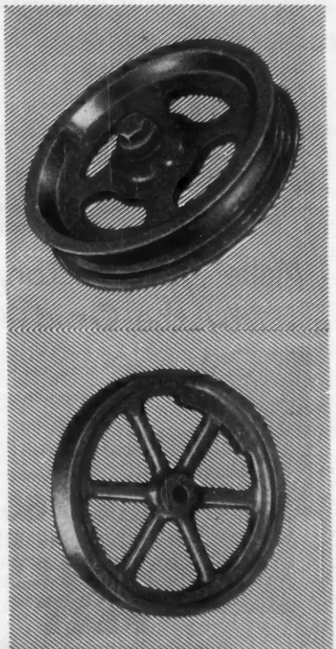

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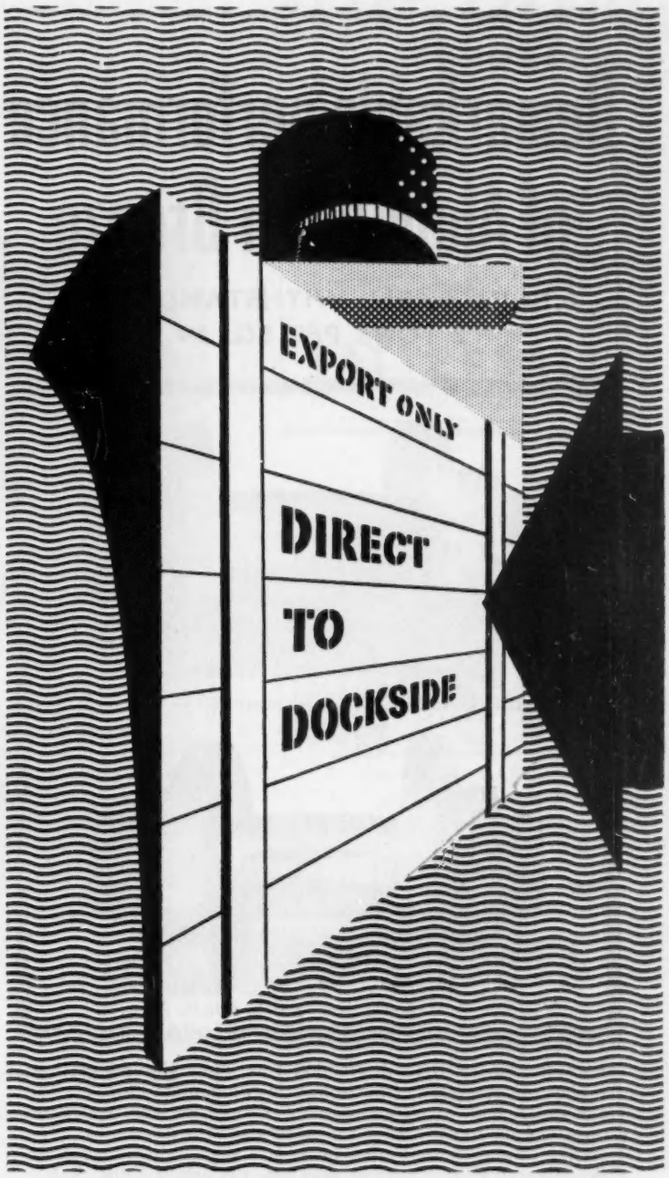

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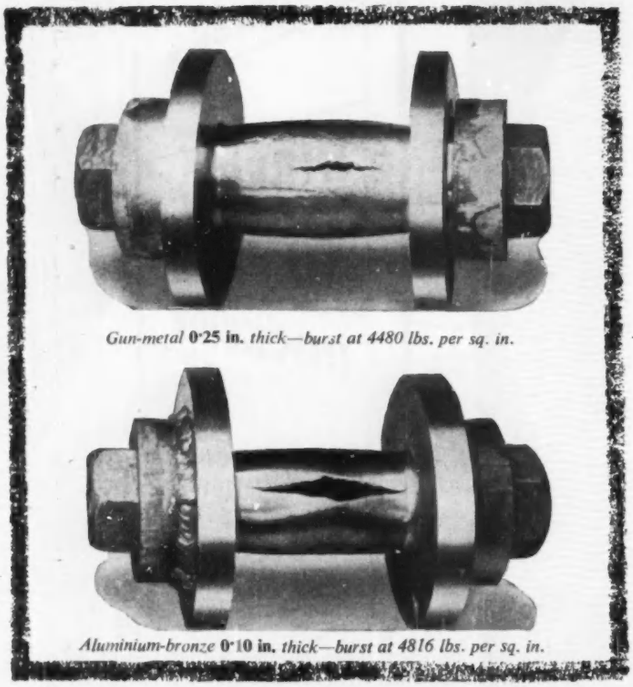

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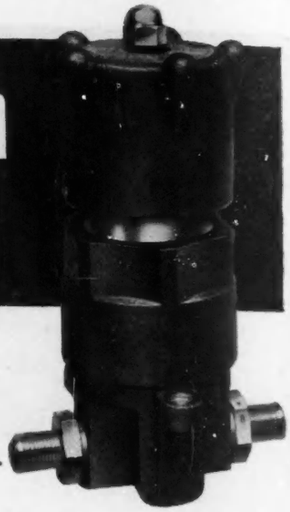

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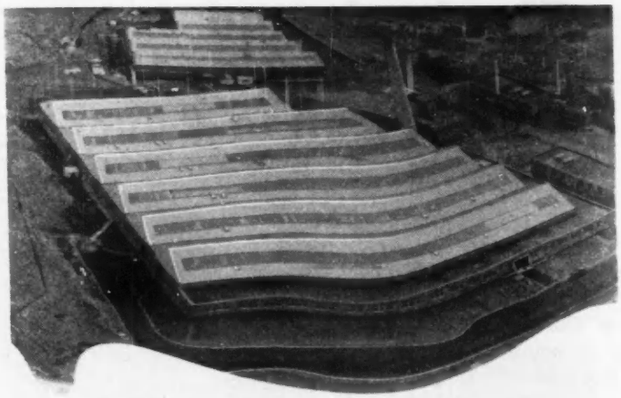

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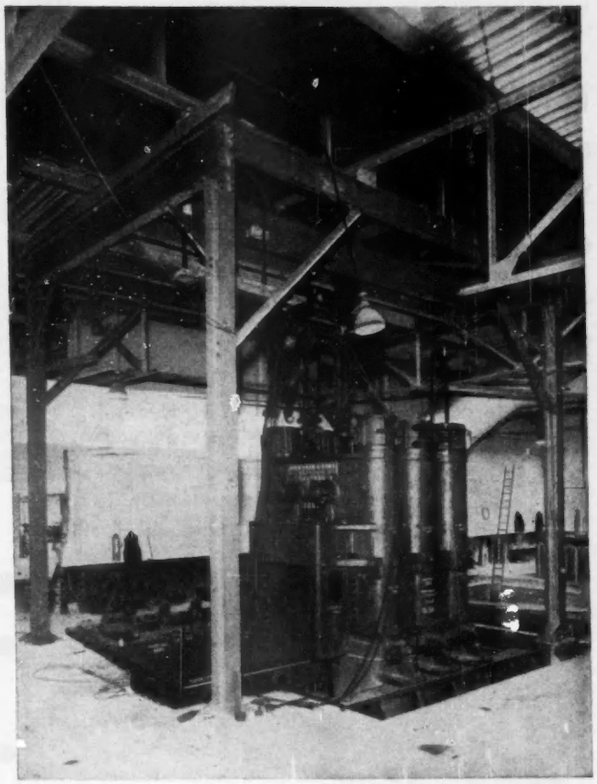

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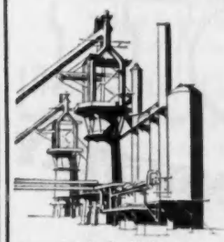

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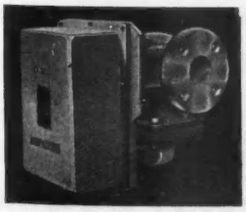

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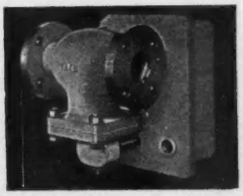

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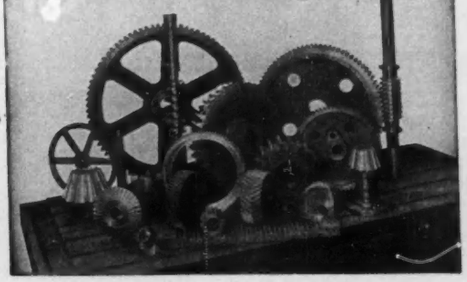

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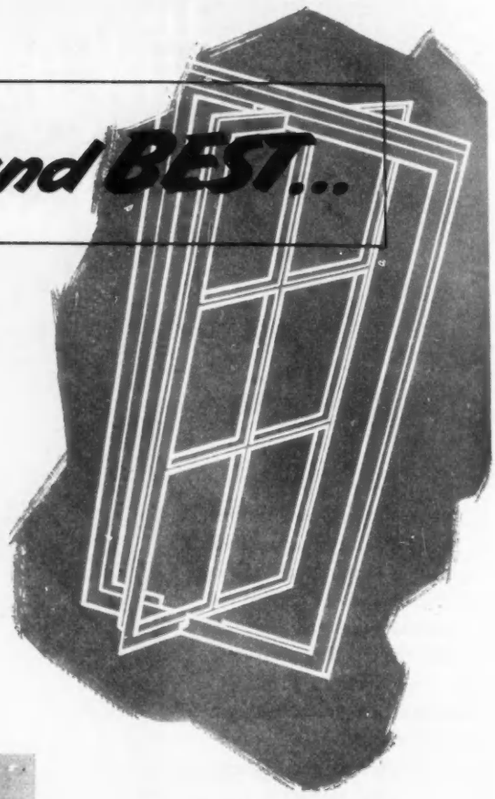

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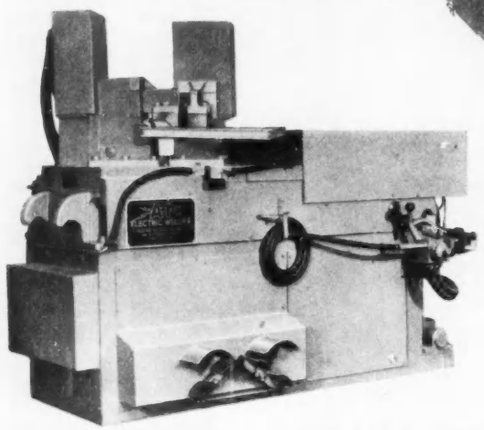

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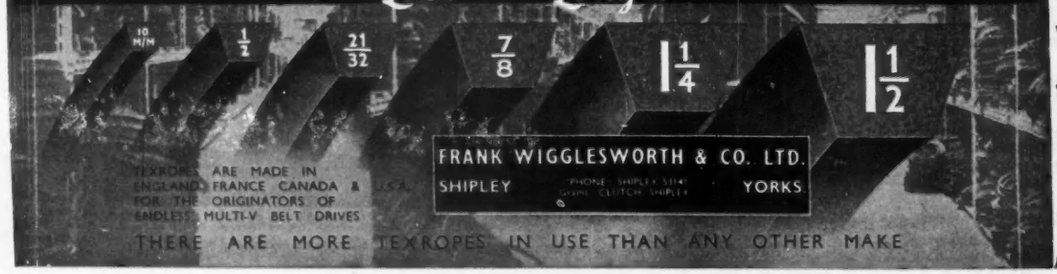

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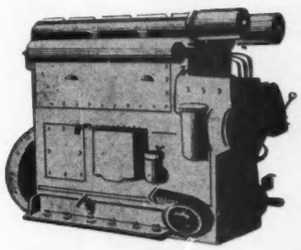

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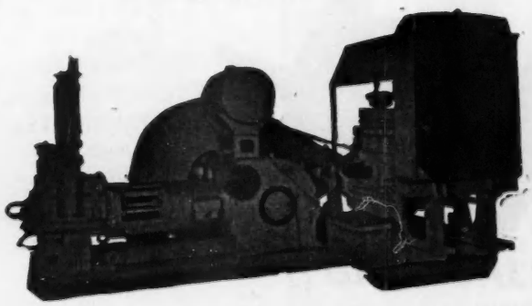

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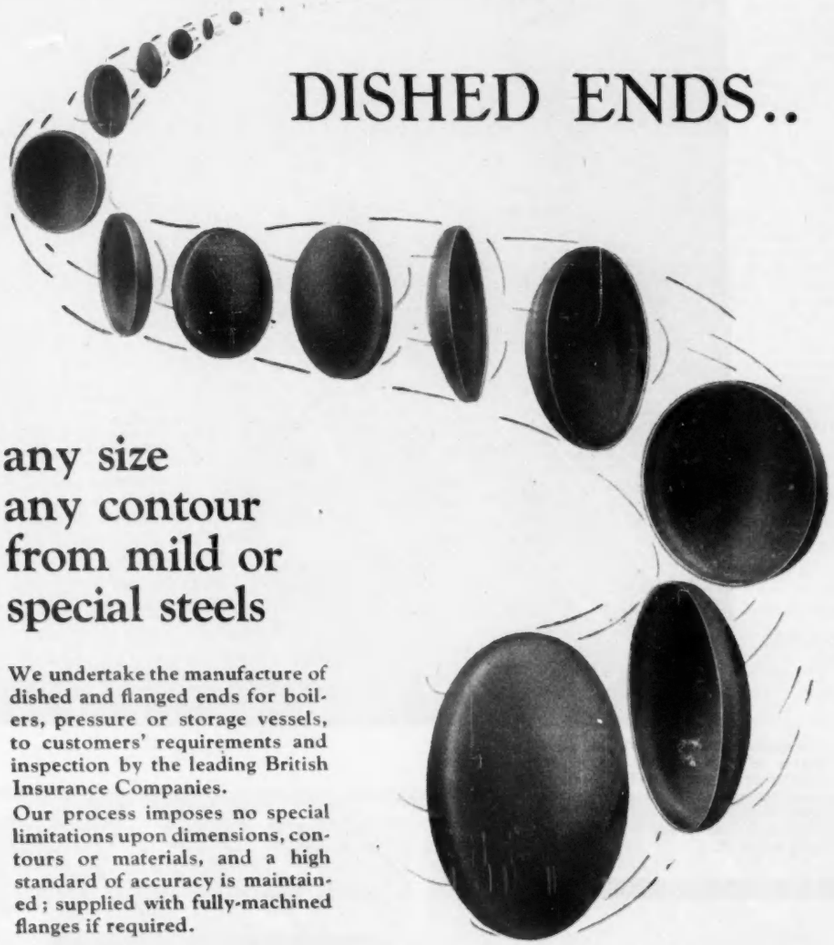

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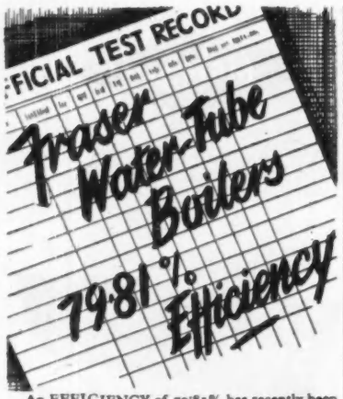

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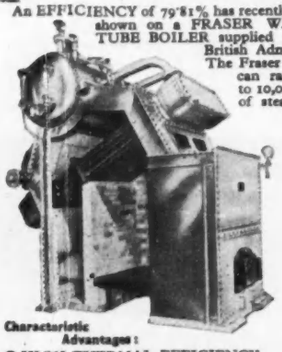

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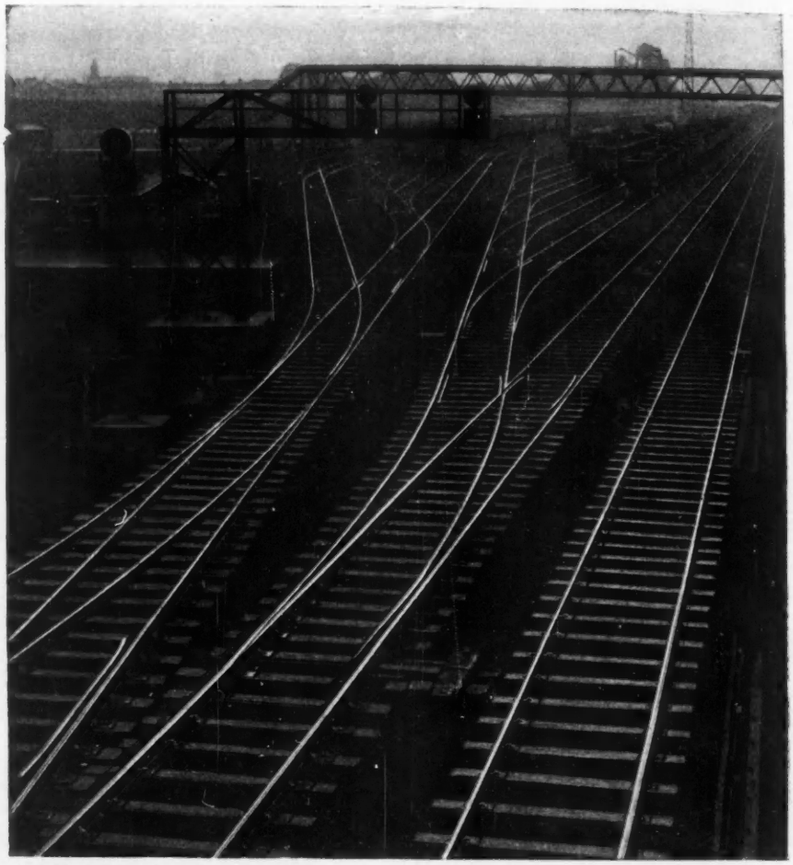

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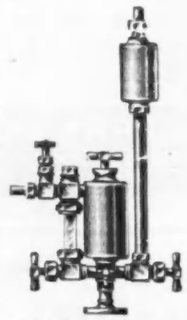

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Classified Advertisements continued from Page 4

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Applications should be addressed to the SECRETARY, SKETCHLEY DYE WORKS, HINCKLEY, LEICESTERSHIRE, and marked "Confidential." M 260

DRAUGHTSMEN/DESIGNERS required by London Office of the SHELL PETROLEUM COMPANY LIMITED. Fully experienced in one of the following categories: (1) Structural steelwork, with some experience of R.C. structures and foundation work preferred; (2) mechanical or general engineering. Preferably between the ages of 30 and 40. Salary according to age and experience. Pension scheme. Canteen facilities. Social and sports club facilities.—Please apply in writing, giving full details, to STAFF DEPARTMENT (R), ST. HELEN'S COURT, GREAT ST. HELEN'S, LONDON, E.C.3. M 285

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CIVIL ENGINEERING MANAGER. Leading British Company with international organisation requires services of Qualified Civil Engineer to take control of major projects. The company has headquarters in London and will only consider applications from fully qualified civil engineers holding University degrees in civil engineering or Associate Membership of the Institution of Civil Engineers. The successful applicant will be required to take complete control of large civil engineering projects each representing several million pounds in value. Extensive experience in the organisation, design, and costing of large civil engineering works is essential. The appointment will be based on London headquarters and carry a salary within a scale of £3,000 to £4000, dependent on qualifications and experience. Pension scheme and assistance for house purchase are available. Applications stating age, experience, qualifications and present salary, which will be treated in strictest confidence, should be sent to BOX M 80, Offices of ENGINEERING.

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West London Water Treatment Engineers require **ASSISTANT FOR TECHNICAL SALES,** having engineering or chemical degree. Pension Scheme.—Apply with full details of qualifications and experience to BOX M 230, Offices of ENGINEERING.

CHIEF ENGINEER. Leading British Company with overseas connections requires a Chief Engineer to supervise the civil, mechanical and electrical constructional work on site of a major engineering project. Applications will be considered only from senior engineers with wide experience of such work. The post is a home appointment and depending upon experience, carries a salary in the range £2,600 to £3500. Amenities include a house purchase scheme and pension fund. Applications will be treated as strictly private and confidential and should state age, qualifications, experience and present salary to BOX M 81, Offices of ENGINEERING.

GRADUATE ENGINEERS (MECHANICAL) required immediately for a progressive Chemical Industry located in the North of England. These vacancies are for design work in the Chief Engineer's Department and are of special interest to young engineers with a flair for design and development work who have served a Graduate Apprenticeship. The age range is 26/33 and the salary within the range £1000/£1500 depending upon age, qualifications and experience. There is a scheme for assisting married men with house purchase and removal expenses. Annual bonus and Pension Schemes are attractive.—Applications, which will be treated with the strictest confidence, to BOX M 195, Offices of ENGINEERING.

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Large Civil Engineering Company with Headquarters in the Liverpool area, carrying out railway electrification schemes require to expand their technical and drawing office staffs immediately. Applications are accordingly invited from
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Classified Advertisements continued on Page **122**

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Present holiday arrangements will be honoured.

Apply to Personnel Manager, giving age and full details of training and experience. M 152

A large industrial company in the South of England is engaged on a programme of expansion running into several million pounds. The programme not only includes extensions to existing plants, but provides also for increased activity into relatively novel fields. The individual projects vary in character and involve all types of engineering from light precision machine work to heavy process equipment, and include all the planning, layout and procurement associated with the design and erection of large manufacturing units.

To help this programme forward, the company proposes to engage

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TECHNICAL DIRECTOR—Leading British Company with headquarters in London wishes to appoint a Technical Director. The position requires an experienced engineer, highly qualified, with wide experience in the design and construction of major engineering projects involving mechanical, civil and electrical engineering. The candidate appointed will have a seat on the Board and will be responsible for the general administration and co-ordination of the design and engineering organisation involving the control of contracts running into several millions of pounds. Applications, which will be treated as strictly confidential, will only be considered from engineers having university degrees and wide experience in the general design of the type of projects referred to in this advertisement. The salary level will be between £3000-£4000. The Company operates a Pension Scheme and facilities for house purchase and removal expenses are available.—Applications should state age, experience, qualifications and present salary, to BOX M 174, Offices of ENGINEERING.

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MORE DRAUGHTSMEN. In particular, men are wanted who are experienced in work associated with chemical plant, e.g., pipework, vessels, heating and ventilating, drying, powder conveying and packing. Mechanical draughtsmen are also wanted, since the programme includes development work in novel processes which are essentially mechanical in nature. In addition, there are vacancies for men with plant instrumentation knowledge. Attractive starting salaries will be paid, and pension and profit sharing schemes are in operation. Special mortgage facilities can be granted towards house purchase and assistance is also available towards removal expenses.—Apply in full to BOX M 138, Offices of ENGINEERING.

METALLURGIST required for Iron Foundry—South East England. Experience of melting, sand control and mechanised production preferred. Pension Fund and Employees' Share-holding Scheme operated.—Write, stating age, experience and salary required, to BOX M 149, Offices of ENGINEERING.

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CONSTRUCTION MANAGER (PROCESS PLANTS), FOSTER WHEELER, LIMITED, 3, IXWORTH PLACE, LONDON, S.W.3. M5

DRAUGHTSMEN required in various drawing offices at Fort Dunlop. There are exceptionally good opportunities for draughtsmen interested in plant layout (including services), special purpose machine design, and tyre design. Promotion comes swiftly to keen and efficient men. There is a good pension scheme. Please write, giving age, experience and salary required, to PERSONNEL MANAGER (M.18), DUNLOP RUBBER CO., LTD., FORT DUNLOP, ERDINGTON, BIRMINGHAM, 24. G 667

TECHNICAL ENGINEER required by WRIGHTS' ROPES LIMITED, BIRMINGHAM, 9, to study design and application of Steel Ropes. Sound practical knowledge mechanical handling and/or mining engineering essential. Previous experience of Steel Ropes not necessary provided adaptable. Pension Scheme.—Write ADMINISTRATIVE OFFICER with full details. M 127

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations, A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter giving details of technical education to the CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. G 665

COMPRESSORS
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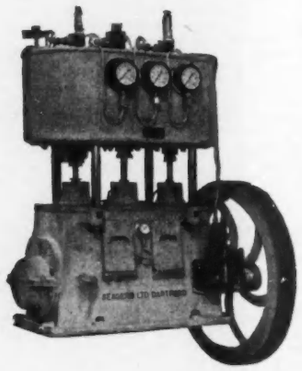
HIGH PRESSURES
and
SPECIAL GASES



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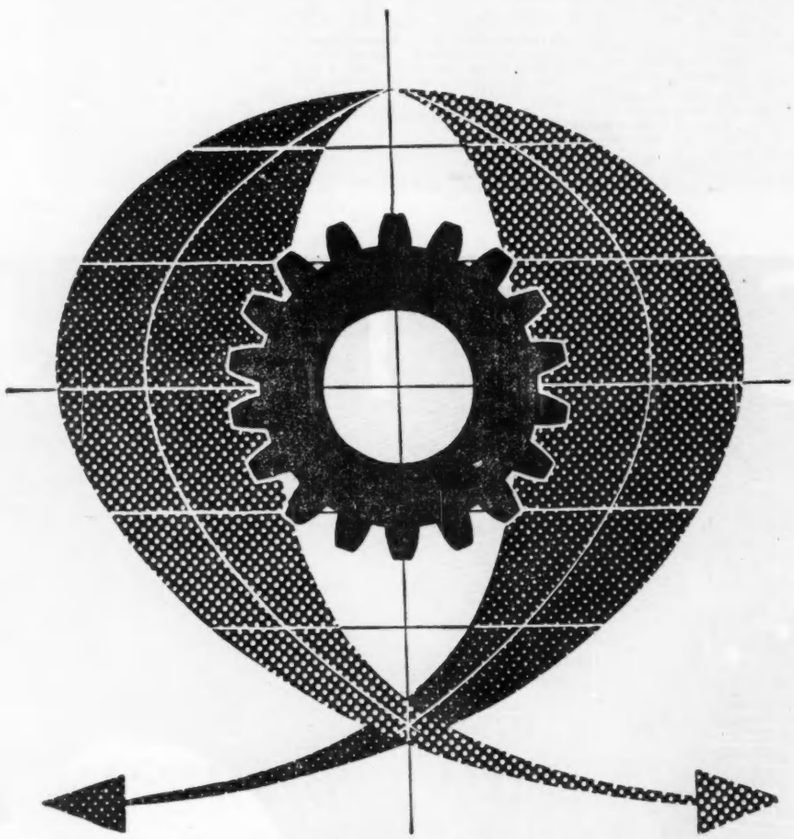

INTERNATIONAL FAIRS

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Brno 8th to 30th September 1956

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A STEP FORWARD IN CLUTCH DESIGN

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ANS

GRADUATE ENGINEERS, AGE 25/30, required to train for executive positions in production and works management in medium/heavy engineering industry producing earth-moving equipment in progressive and up-to-date factory.—Applications in writing in first instance giving all relevant particulars and approximate salary required to PERSONNEL MANAGER, RUSTON-BUCYRUS, LTD., LINCOLN. M 201

DRAUGHTSMEN, SENIOR AND JUNIOR, preferably with Railway or Automotive experience, required for Diesel Traction Drawing Office situated in London area, N.W.10. Apply in writing giving age, details of experience and salary required, to GENERAL MANAGER, BRITISH UNITED TRACTION LTD., 14, HANOVER SQUARE, LONDON, W.1. M 87

GENERAL MANAGER, capable of becoming Managing Director of Company in twelve months, required for Mechanical Toy Factory in London. Responsibilities will include direct control of all phases of production and production engineering from prototype to finished article. Factory Company is part of a group and sales and finance are handled by head office. Applicants should hold H.N.C. or membership of recognised engineering institution. Adequate four-figure salary with participation in profits and contract if successful after initial period.—Reply to BOX M 254, Offices of ENGINEERING.

A.V.R.O.

WEAPONS RESEARCH DIVISION

A. V. ROE & CO., LTD.

INSTALLATION ENGINEER

required for design and development work connected with the ground and air launching of guided missiles. This is a senior staff position carrying a good salary and prospects of advancement in an expanding organisation. The Company has a Pension and Life Assurance Scheme, and the division is situated in pleasant surroundings with convenient access to Stockport and Manchester. Applicants should possess an Engineering Degree or H.N.C., and several years' design experience. Experience of Armament Installations would be an advantage.—Applications to:—

Chief Engineer,
Weapons Research Division,
A. V. Roe & Co., Limited,
Woodford, Cheshire.

M 250

For proved performance...

BTR CONVEYOR BELTING

The vast Bromley-by-Bow Gas Works, supplying a highly industrialised, densely populated area, relies for its mechanical handling on BTR Conveyor Belting. From barge to Retort House, from Retort House to coke hoppers, the continuous and efficient performance of the entire network is closely bound up with the strength and load-carrying ability of this belting.

Conveyor systems in many large gas works, like Bromley-by-Bow, are equipped throughout with BTR belting—for long service life, low maintenance costs and non-stop efficiency under really arduous conditions. FOR PROVED PERFORMANCE . . . insist on BTR CONVEYOR BELTING.

Main coal conveyor about 830 ft. long equipped with 30 in. wide BTR conveyor belting travelling at 350 ft. a minute, designed to carry 200 tons of coal an hour.

BTR

ENGINEERS IN RUBBER

BRITISH TYRE & RUBBER CO. LTD HERGA HOUSE, VINCENT SQUARE, LONDON S.W.1

DI104

A well established company in the field of glass engineering have a vacancy for a **SENIOR EXECUTIVE APPOINTMENT OF TECHNICAL MANAGER.** Candidates should possess a university engineering degree, have executive experience and experience in design and development problems. The post offered provides an attractive opening for any individual who has the qualifications of a senior executive with a sound background of engineering training and experience **BUT PREVIOUS EXPERIENCE IN THE GLASS INDUSTRY ALTHOUGH DESIRABLE IS NOT ESSENTIAL.** The salary offered will be substantial and commensurate with the experience and ability of the individual selected. —Applications, giving age (between 35-50), details of experience and salary required, should be addressed to THE ASSISTANT MANAGING DIRECTOR, BRITISH HARTFORD-FAIRMONT LIMITED, ROCKWARE AVENUE, GREENFORD, MIDDLESEX, and the envelope marked "Private and Confidential." M 227

An important Company engaged in the design and development of major guided weapon projects require

AN EXECUTIVE ASSISTANT for ADMINISTRATIVE DUTIES

The successful candidate must be trained in electronic or electrical engineering and the qualifications should include a University Degree or similar standard of attainment in the Services, and in addition workshop experience would be an advantage.

Applicants should be proficient in administration and be familiar with committee and associated office procedure. Their age should be not less than 30, although consideration would be given to an applicant below this limit in exceptional circumstances.

This is a responsible position and will carry an attractive salary and excellent prospects.

Pleasant working conditions and amenities are provided and a generous pension scheme is in operation.

Replies will be treated in the strictest confidence and should be addressed to:—

T.A.O., BOX G 671, Offices of ENGINEERING, quoting reference: Comp/5.

Classified Advertisements continued on Page 124

Senior Development and Design Engineers

Appointments exist in the Development and Design Department

OF

BRITISH OXYGEN ENGINEERING LIMITED

for Engineers with the minimum qualifications of Second Class Honours Degree and experience in a senior capacity on mechanical engineering design.

The appointments will entail responsibility for complete projects covering special purpose machine design in the cutting and welding field.

For people joining the Company from outside the North London area it is of interest that the Works are within easy travelling distance of North London residential areas verging on the green belt of Middlesex and Hertfordshire and on Epping Forest.

FULL ASSISTANCE TOWARDS PURCHASE OF HOUSES WILL BE GIVEN TO SELECTED APPLICANTS AND REMOVAL AND LEGAL EXPENSES PAID

Applications should be addressed to:

THE PERSONNEL MANAGER,
BRITISH OXYGEN ENGINEERING, LTD.,
ANGEL ROAD,
EDMONTON,
LONDON, N.18. M 214

SPURS · SPIRALS · BEVELS
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CHAINWHEELS · SILENT PINIONS

SUPPLIED COMPLETE OR CUTTING ONLY

W. L. SONES & SON BRADFORD GEAR WORKS, Lidget Green, BRADFORD, 7
GRAMS: *INVOLUTE.* PHONE: BRADFORD 71112.

MECHANICAL/ELECTRICAL ENGINEER required for old-established Mining Company in Malaya. Thorough technical and practical training with wide experience of mining machinery essential. Electrical experience desirable but not essential. Good salary offered in accordance with qualifications. 3/3½ year contract with free house, light, water, medical, Provident Fund, passages and six months fully paid leave on completion with renewal of contract if mutually satisfactory.—Replies to W. R. LOXLEY & CO. (LONDON), LTD., PLANTATION HOUSE, FENCHURCH STREET, LONDON, E.C.3. M 209

FUEL ENGINEERING ASSISTANT for Development Department of large group of companies. Work involves efficiency surveys of factories or sections thereof, Fuel Economics and preparation of Schemes for installation of new plant. The work covers a range of equipment including high temperature furnaces, steam boilers, space heating and ventilation equipment, etc. Applicants should hold a degree in Science or Engineering. Pension Scheme.—State qualifications, experience and salary required to PERSONNEL MANAGER, TUBE INVESTMENTS (GROUP SERVICES), LIMITED, ROCKY LANE, ASTON, BIRMINGHAM, 6. M 218

RESEARCH SCIENTIST required for interesting new developments in domestic heating. Candidates should have a degree or equivalent in Physics. Previous research experience is not necessary, but applicants must have an aptitude for original work and the ability to apply a scientific training to practical objectives. The work is concerned with recent developments, and offers opportunities for training and experience in modern research techniques and instrumentation in exceptionally well-equipped laboratories. The post also offers opportunities for publishing the results of successful research and good prospects of advancement for graduates with research ability. Starting salary in range £600-£900. Five-day week. Superannuation and Grading Schemes.—Apply in writing to ASSISTANT SECRETARY, REF. C.35, B.C.U.R.A., RANDALLS ROAD, LEATHERHEAD. M 219

UNILEVER, LTD., invite young **MECHANICAL ENGINEERS** to apply for a post at Silvertown, London, E.16. University degree or equivalent engineering qualification and works training essential. Subsequent industrial experience (especially in Maintenance work) desirable. The duties will include the operation of a Planned Maintenance Scheme throughout the factory, under the guidance of the Chief Engineer. Preferably, candidates should be aged 25/30.- Contributory Superannuation Fund and Widows Pension Scheme.—Applications should be addressed to: UNILEVER, LTD., PERSONNEL DIVISION (WAD 120), UNILEVER HOUSE, BLACKFRIARS, LONDON E.C.4. M 225

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED
ARMAMENTS DIVISION
A SENIOR ENGINEER

is required for work on Analogue Computers. Applicants should have a degree in electrical or mechanical engineering, and be thoroughly conversant with the theory of analogue computing. In addition a number of years' experience covering the design and use of computers of this type is required.

This is a senior position of considerable interest and responsibility, and it will offer ample scope to an Engineer well versed in the theory and practice of this type of work.

An attractive salary will be payable and a generous pension scheme is in operation.

All applications will be treated in the strictest confidence and you are invited to apply to:

TECHNICAL APPOINTMENTS OFFICER,
SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD.,
BAGINTON, Nr. COVENTRY.
Quoting reference: Comp/4 G 672

stop digging . . .

drill it with a

"SPEEDICUT"
HIGH SPEED STEEL
DRILL

F. H. BROWN TOOLS LTD.

SPEEDICUT WORKS · CARLISLE STREET EAST · SHEFFIELD

VISIT OUR STAND No. 305, GRAND HALL GALLERY, at the MACHINE TOOL EXHIBITION 22nd June-6th July

DESIGNERS for work of interest in the design of special purpose machinery and equipment for the Automatic Manufacture and assembly of the Company's products in the Walsall area. There are good working conditions and a contributory pension scheme. Applications will be dealt with in strictest confidence.—Particulars of age, experience, qualifications and salary required to BOX M 216, Offices of ENGINEERING.

Applications are invited for the position of **ASSISTANT ELECTRICAL ENGINEER** with an Electricity Supply Company in Nigeria. Age should not exceed 30 years and Corporation Member or Graduate I.E.E. preferred. Salary £75 per month, length of tour 18 months, free passage, quarters and medical attention. There is also a pension scheme.—Write BOX W.178, c/o STREET'S, 110, OLD BROAD STREET, E.C.2. M 226

DRAUGHTSMEN required by NORTHERN ALUMINIUM COMPANY, LTD., BANBURY, OXON. Qualifications: H.N.C. preferred, but O.N.C. considered, workshop training an advantage. Permanent positions to suitable applicants. Pension and Life Assurance Scheme in operation, also welfare and sports facilities.—Write PERSONNEL MANAGER, stating age, experience and salary required. M 257

SENIOR STRUCTURAL DESIGNER/DRAUGHTSMAN AGED 30 TO 40 required for large British managed engineering Company in Calcutta, manufacturing major bridges, steelwork buildings, cranes of all types and capacities, sluice gates and other steelwork both riveted and welded. Excellent prospects and terms.—Write BOX JN/95, c/o 95, BISHOPSGATE, E.C.2. M 234

MEKELITE

GEARED JOINT

INDUSTRIAL LIGHTING UNITS

For wall, bench or machine mounting. *Catalogue sent free on request.*

MEK-ELEK Engineering Ltd., 17 Western Road, Mitcham, Surrey

Phone: MITcham 3072 Cables: Mekelek, London

WORKS MANAGER

FOR

AERO ENGINE RESEARCH

AND

DEVELOPMENT PROGRAMME

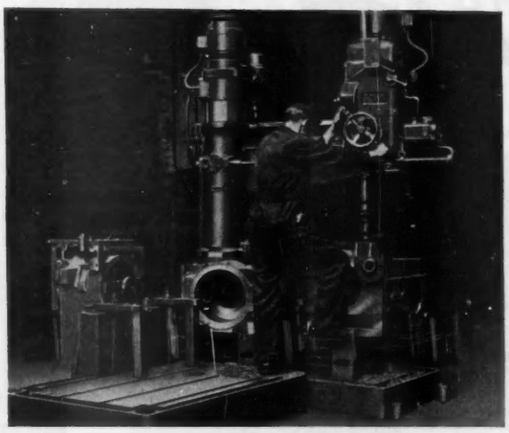
A well-known Company invites applications from Engineers of suitable experience and proved administrative ability for the above appointment.

Applicants who should be under 45 must be well qualified and capable of undertaking full responsibility for all manufacturing departments and workshops, undertaking an interesting and expanding experimental programme of national importance.

The position provides excellent prospects for advancement along with a good salary and Pension Scheme to a man possessing first-class leadership and initiative.

Applications, which will be treated in strict confidence, should give full details of experience, qualifications, etc., and be addressed to BOX AC.20148, SAMSON CLARKS, 57-61, MORTIMER STREET, LONDON, W.1. M 170

they go to Town . . .



In the production line, this A.E.I. type Radial is drilling and tapping ¾in. B.S.F. and 1in. B.S.P. holes in a Crawler Tractor gear box.

Three-way base-plate set-up uses machine to its maximum capacity.

at Marshall Sons and Co. Ltd.

GAINSBOROUGH—LINCS

In the toolroom, an A.E.I. type Radial is used for accurate work, in this case drilling a jig plate, the holes having been plotted previously on a jig-boring machine.

ESTABLISHED 1903

FRED^K TOWN & SONS LTD

HALIFAX · YORKS

DESIGN ENGINEER. A vacancy exists for a Design Engineer interested in special-purpose automatic machines and fine mechanisms for mass production of light engineering products. The work is interesting, gives scope for initiative, has excellent prospects, and comprises the design of an entirely new series of production machines. Applicants should have an engineering degree, or H.N.C. with endorsements, and experience in mechanical design. The salary will be dependent on qualifications and experience.

DEVELOPMENT ENGINEER. A development engineer is also required to work in conjunction with the design engineer. His duties would comprise study of production techniques, preliminary trials of new processes, try-out of prototype machines and test runs on final machines on a pilot plant to ensure suitability before being put on to production. Applicants should have H.N.C. or equivalent and good practical experience, preferably on development work. The salary will depend on qualifications and experience.

DESIGNER-DRAUGHTSMAN. A few vacancies also exist for designer-draughtsmen and draughtsmen engaged in the above work under the design engineer. The work is interesting and there are excellent prospects for men with initiative and drive. Applicants should have at least H.N.C. (designer-draughtsman) or O.N.C. (draughtsman). All these appointments are in the London area and with a very large and long-established Company. —Applicants should write to BOX M 280, Offices of ENGINEERING.

INSTRUMENTATION.

TECHNICAL ASSISTANT required for work on design and installation and operation of experimental automatic control equipment in the Textile and Chemical Engineering fields. Previous experience in at least one branch of Mechanical or Electrical Industrial Instrumentation is preferred but a candidate with Electrical Design and Drawing Office experience would be considered eligible. The post is an interesting one in the Research and Development Department and offers excellent prospects of promotion in an expanding field. Minimum qualifications are Higher National Certificate in Electrical or Mechanical Engineering.

Apply in the first instance by letter giving age, qualifications and experience to the LABOUR OFFICER, COURTAULDS LIMITED, MAIN WORKS, FOLESHILL ROAD, COVENTRY. M 259

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

RESEARCH ASSISTANT required by the Civil and Structural Section of the Plant Engineering Division of the Association in London for interesting and varied research for a basic and expanding industry. Duties will include stress measurements on model and full-scale steelworks structures in the London laboratories and on site, and computing test results. Candidates should have at least an Ordinary National Certificate or equivalent qualifications in civil or mechanical engineering. Time off for further study will be given. Starting salary up to £650 p.a. according to age, qualifications and experience. Five-day week. Staff pension scheme.—Written applications only, quoting "C.E.9," to the PERSONNEL OFFICER, B.I.S.R.A., 11, PARK LANE, LONDON, W.1. M 281

Required by large, progressive and old-established Manufacturing Company in South West England, **A CHIEF DRAUGHTSMAN** for the Engineering Drawing Office employing 20/24 draughtsmen. The work entails plant layouts, extensions, special equipment and machine design, general routine work involved with a large factory using comprehensive equipment and services. Applicants should already have had experience in this capacity and should give full particulars. A salary commensurate with the responsibilities and experience involved will be paid, and assistance will be provided regarding accommodation during the early months after taking up the appointment.—BOX M 217, Offices of ENGINEERING.

Classified Advertisements continued on Page 126

SUB-AGENTS AND ASSISTANT ENGINEERS (QUALIFIED) required for contracts in Midlands and London area. Previous site experience on heavy civil engineering works necessary. Good salary and prospects for right men. Pension scheme. —Write with full details to BOX M 233, Offices of ENGINEERING.

FERODO, LIMITED, CHAPEL-EN-LE-FRITH Via STOCKPORT, have vacancies for the following:—

1. **GENERAL ENGINEERING DRAUGHTSMEN,** age 25 to 40, having experience in Machine Design and Works Layouts. A knowledge of Works Building Design desirable but not essential. Technical education at least to O.N.C. Ref. 2444/1.

2. **JIG AND TOOL DRAUGHTSMEN,** age 25 to 40. A knowledge of General Engineering and Machine Design advantageous but not essential. Technical education at least to O.N.C. Ref. 2444/2.

Suitable applicants are offered excellent working conditions and canteen facilities. There is a contributory superannuation scheme.

You are invited to submit full details of experience, age, qualifications and salary required to THE PERSONNEL MANAGER, quoting the appropriate reference number. M 222

DRAUGHTSMEN.

EDWIN DANKS & CO. (OLDBURY) LTD., OLDBURY, NR. BIRMINGHAM—manufacturers of all types of Pressure Vessels have vacancies for **SENIOR DRAUGHTSMEN AND DETAILING DRAUGHTSMEN.** The work, which is interesting covers a wide field in the design of all classes of welded vessels for Industrial Plants, Chemical Plants and Oil Refining Plants.

The positions are permanent, and the Company has a contributory pension scheme and other facilities and conditions associated with first-class employers.

Applicants should be competent men, able to work with a minimum amount of supervision.

Please write, giving age, details of training and experience.

Salary according to qualifications and experience, interesting work and canteen facilities provided.

Apply:—CHIEF ENGINEER, EDWIN DANKS & CO. (OLDBURY) LTD., OLDBURY, NR. BIRMINGHAM. M 180

AERO ENGINE CONTROL SYSTEM.

ENGINEERS are required for a newly formed department dealing with various theoretical aspects of aero engine control problems. Experience of servo mechanism analysis and gas turbine engine performance investigation is desirable.—Applications quoting END to TECHNICAL PERSONNEL MANAGER, ARMSTRONG SIDDELEY MOTORS, COVENTRY. G 658

EXPERIENCED PLANNING ENGINEERS required for production methods on medium I.C. engine components and fuel injection equipment. Pleasant working conditions, generous salary. Attractive Pension Scheme and Comprehensive Welfare Facilities.

Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES, MIDDX. G 662A

STRUCTURAL ENGINEER required by London firm of Consultants to take charge of their steel design office. Candidates must have a comprehensive knowledge of all types of structural steelwork both designing and detailing and should preferably have had some works experience. Applicants should be Corporate Members of one of the senior professional Institutions or hold similar Degrees. The post is a permanent one and there is a Staff Pension Scheme.—Please reply in confidence to BOX NO. 389, GLOVERS ADVERTISING, LTD., 351, OXFORD STREET, W.1. G 643

THE SUPERHEATER CO., LTD., 53, HAY MARKET, LONDON, S.W.1, has vacancies fo **TECHNICAL DESIGN ENGINEERS.** Knowledge of Thermodynamics, including Combustion and Heat Transfer desirable.

Good working conditions, 5-day week. Pension Scheme.—Write giving full details of qualifications, experience and salary required. M 163

Made by James Neill & Co. (Sheffield) Ltd., and obtainable from all tool distributors UHJ

Get tough with that hose clip!

. . . but don't expect an ordinary clip to put up with the treatment the Cheney Connect was designed to withstand. Protected by many patents, the Cheney Connect is the strongest, most efficient hose clip ever made — and the easiest to fit and adjust. Refit all round with the Cheney Connect NOW.

FENTER FOR THE CHENEY CONNECT

Trade enquiries to:
FENTER LTD., 184, ASTON ROAD, BIRMINGHAM.

JAMES WILEY & SONS LTD

BOLTS & NUTS

OF QUALITY

BRIGHT NUTS

DARLASTON S. STAFFS.

BRITISH CELLOPHANE LIMITED, BRIDGWATER, SOMERSET, seeks

SENIOR AND JUNIOR DRAUGHTSMEN, for both **PERMANENT** and **TEMPORARY** appointments, for work on machine design and chemical plant layout. Applicants should possess at least O.N.C. and have had three years' shop experience. Five-day week, Pensions Fund Scheme for permanent appointments. Ref. No. E56.Eg. **THE TEMPORARY** appointments are for a period of approximately two years' duration, subject to three months' notice and include generous subsistence allowances, and periodic home return rail fares.

ASSISTANT ENGINEER, AGE 23/30 (PERMANENT.) Applicants should have an honours degree in mechanical engineering and have had some practical works experience. The duties will be on development, improvement and maintenance of chemical and other plant. Ref. No. E57.Eg.

SECTION LEADER DRAUGHTSMAN (PERMANENT) in connection with the design of factory services. Applicants should possess H.N.C., have had at least three years' shop experience, and be familiar with all types of pipework installations. Ref. No. E58.Eg.

ASSISTANT ENGINEER, AGE 25/30 (PERMANENT.) Applicants should have a university degree and have works experience, or be an A.M.I.Mech.E. The duties will be on development, improvement and maintenance of plastic films extrusion plant and ancillary equipment. Ref. No. R48.Eg.

Write to the Personnel Officer, stating full particulars and salary required, and quote Ref. Nos a sindicated. L 970

PRODUCTION MANAGER

required by old established Company engaged in the construction of Pressure Vessels and other Welded Fabrications of Mild Steel, Stainless Steel and other Metals.

Applicants should be about 35 years old and have served an Indentured Apprenticeship in Engineering.

Production experience in a supervisory capacity is essential, also a thorough knowledge of methods of payment including incentives.

The job is an important one and will carry a substantial salary. There are excellent prospects for a suitable man with drive and initiative.

Apply in confidence giving full details of education and career to date, to:—

MANAGING DIRECTOR,
JOHN THOMPSON (DUDLEY), LIMITED,
DUDLEY,
WORCS. M 215

THE SUPERHEATER CO., LTD., 53, HAYMARKET, LONDON, S.W.1, has vacancies for **DRAUGHTSMEN.** Experience of Water Tube Boilers preferred.

Good working conditions. 5-day week. Pension Scheme.—Write giving full details of qualifications, experience and salary required. M 164

DESIGN ENGINEER.

COURTAULDS LIMITED requires a **DESIGN ENGINEER** at its Engineering Headquarters in Coventry for development work on man-made fibre-making plant and machinery. A good engineering degree is essential, and several year's industrial experience in the design and development of chemical, textile, or allied process plant and machinery is desirable. Age 27 to 40. Applicants should have an aptitude for solving design problems and calculations in this type of engineering.

Candidates should write giving full personal particulars and details of experience to the DIRECTOR OF PERSONNEL, COURTAULDS LIMITED, 16, ST. MARTINS-LE-GRAND, LONDON, E.C.1, quoting reference number B.36. L 925

THOMAS GLOVER & COMPANY invite applications for the position of

ASSISTANT WORKS MANAGER at their Edmonton factory. Applicants should possess proved administrative ability and have had considerable experience of production methods in the Light Engineering Industry. Age 30 to 45 years. Commencing salary will be not less than £1250 per annum with good prospects. A superannuation scheme is in force.—Applications stating age, qualifications, experience and present salary should be addressed to the MANAGING DIRECTOR, T. GLOVER & CO., 48, GROSVENOR GARDENS, LONDON, S.W.1. M 189

Heavy Engineers in the Trafford Park Area require **A WELDING SUPERVISOR** who must be experienced in gas and electric welding. Also familiar with argon and submerged arc processes. Experience of flash and spot welding desirable. Some metallurgical knowledge essential. This is a superannuable position with excellent prospects. Applicants must give full particulars and mark applications for the attention of the PERSONNEL MANAGER.—BOX L 976, Offices of ENGINEERING.

DRAUGHTSMAN required for Engine Design Schemes on small high-speed diesels must have initiative and experience. Good salary. Pleasant working conditions. Pension Scheme.—Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES. G 650

SENIOR AND JUNIOR DESIGNERS for reinforced concrete and/or steelwork required for London Office. Considerable scope for advancement. Junior assisted in study courses involving day attendance. Consideration given to holiday arrangements.—BOX M 42, Offices of ENGINEERING.

ENGINEER

required by firm in Hertfordshire to be trained for an executive position. Applications are invited from Mechanical Engineers aged 35-40, of good education, technical qualifications and sound practical training, including design. Experience of modern works management and production desirable. Knowledge of Civil and Electrical Engineering an advantage. Salary offered will be commensurate with qualifications and experience.—Replies, which will be treated with strictest confidence, must state age, present position and salary with full details of education, experience and positions held.—BOX M 253, Offices of ENGINEERING.

THE HEAD WRIGHTSON MACHINE COMPANY LIMITED,

invite applications from first-class

DESIGN ENGINEERS AND SENIOR DRAUGHTSMEN

who would be interested in progressive positions in a special development department which will shortly be opened to deal with a wide range of problems affecting several industries.

The Company has a good Pension Scheme and allows generous holidays. Men having a sound technical training and a flair for design are recommended to submit applications marked "Private (Development)," to :—MANAGING DIRECTOR, HEAD WRIGHTSON MACHINE COMPANY LTD., COMMERCIAL STREET, MIDDLESBROUGH. M 157

JUNIOR DRAUGHTSMEN required, O.N.C. standard, experience in general engineering and/or sheet metal fabrications for work on specialized equipment for the Dairy, Brewery and Chemical Industries.

Salary commensurate with experience.—BOX M 179, Offices of ENGINEERING.

SENIOR JIG AND TOOL DRAUGHTSMEN required for Tool Design on

(*a*) Small I.C. Engine components.
(*b*) Fuel Injection and Hydraulic Control Mechanisms on a production basis.

Applicants should have experience in these or similar fields.

Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.

Apply to CHIEF PERSONNEL OFFICER, BRYCE BERGER WORKS, STAINES, MIDDX. G 660

DESIGN DRAUGHTSMEN. The British Drug Houses Ltd. invite applications from suitably qualified men for interesting work in their Engineers Drawing Office, on special machines and plant layouts for the Light Chemical Industry. Higher National Certificate in Mechanical Engineering and previous experience in this industry desirable but not essential. Men of mature age with suitable training and experience would be considered. Five-day week. Pension and Profit Sharing Schemes.—Write stating age, experience and salary required to STAFF MANAGER (REF. B8945), GRAHAM STREET, CITY ROAD, N.1. L 918

HEAT TRANSFER AND FLUID FLOW. Research and Development Engineer required by an old-established Engineering Company in the Glasgow area. Applicants, aged 25-30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. Apply giving age and full particulars to BOX G 583, Offices of ENGINEERING.

DRAUGHTSMEN (SENIOR AND JUNIOR) required for work in connection with the following branches of Coke Oven and Gasworks plants.

(*a*) Mechanical and By-Product Plant.
(*b*) Pipework.
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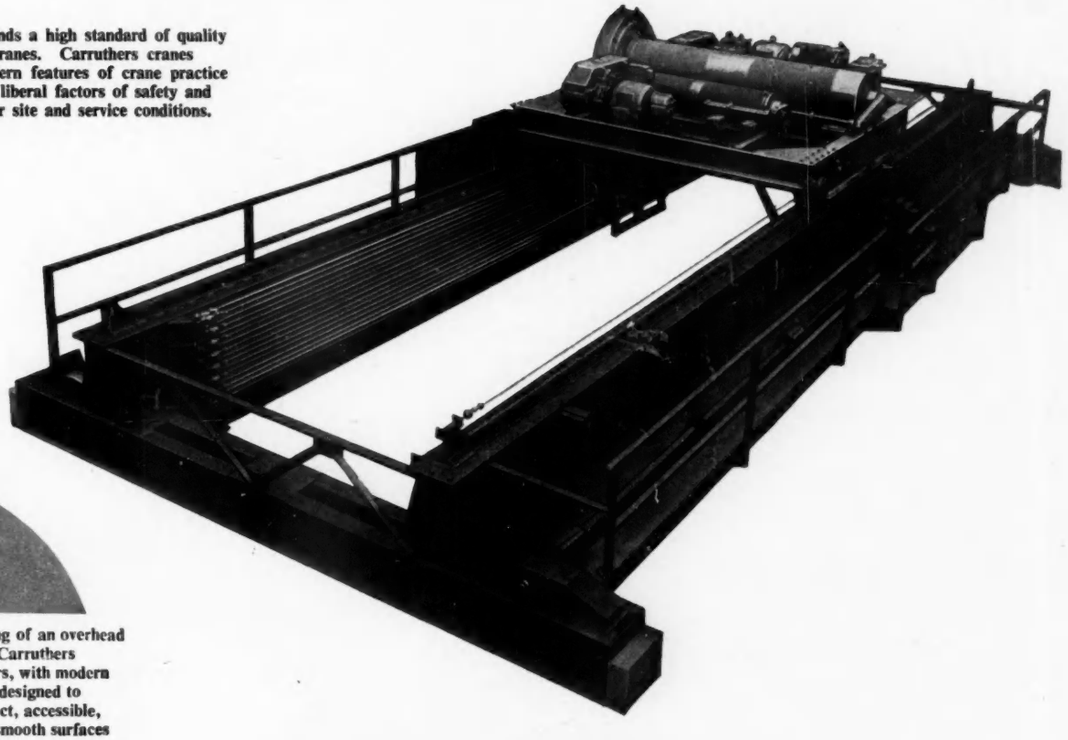

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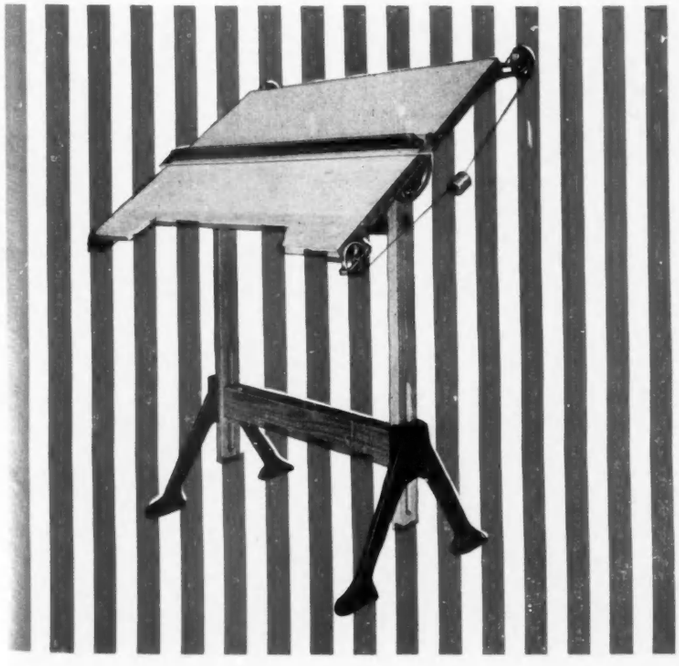

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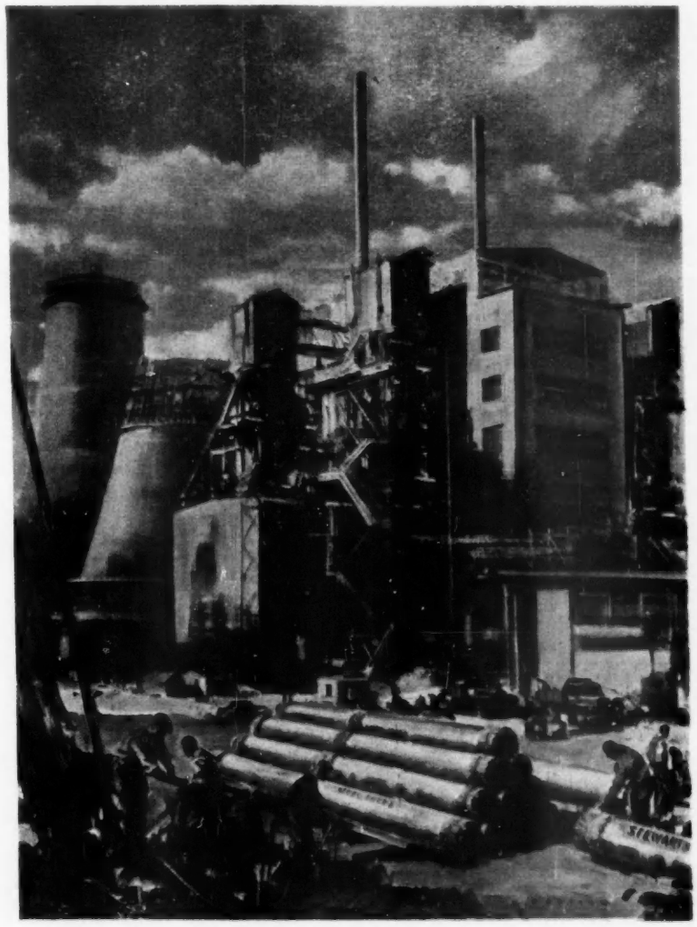

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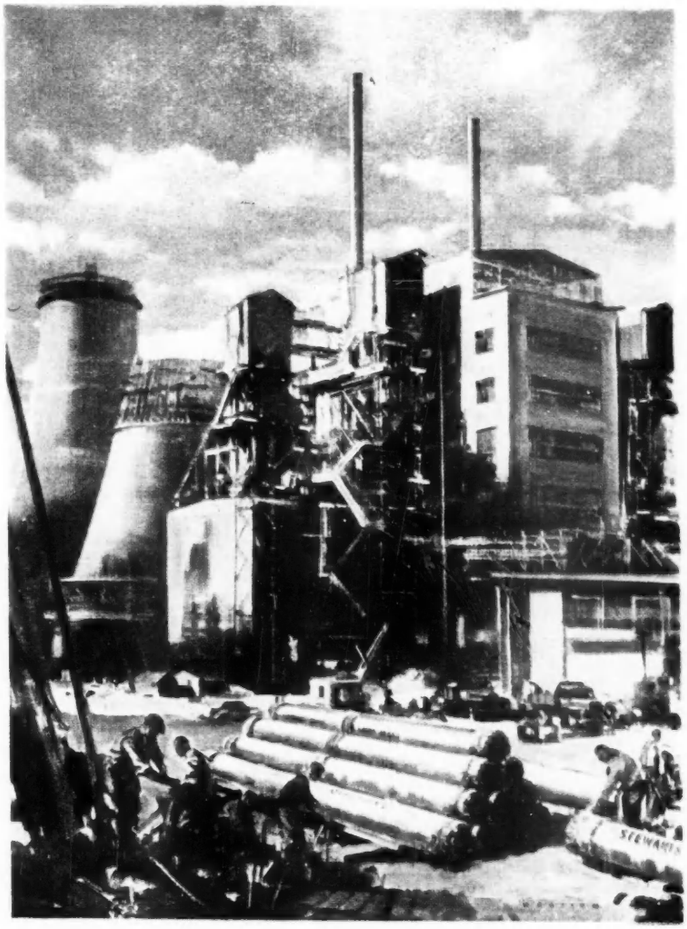

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